ELEMENTS

OF

ELECTRO-BIOLOGY,

OR

THE VOLTAIC MECHANISM OF MAN;

OF

ELECTRO-PATHOLOGY,

ESPECIALLY OF THE NERVOUS SYSTEM;

AND OF

ELECTRO-THERAPEUTICS.

BY

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TO THE ROYAL GENERAL DISPENSARY, ETC. ETC. ETC.

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TO

WILLIAM SMEE, ESQ. F.S.A.

CHIEF ACCOUNTANT OF THE BANK OF ENGLAND,

ETC. ETC.

THIS EXPLANATION OF

THE VOLTAIC MECHANISM OF MAN

IS DEDICATED:

IN THE ASSURANCE THAT IT WILL BE ESTEEMED

AS A TRIBUTE OF FILIAL AFFECTION,

FROM HIS DUTIFUL SON,

ALFRED SMEE.

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FIG.

1. Astatie Galvanometer, eonsisting of two magnetised needles suspended by a piecc of silk-worm's silk. For its employment, great care must be taken that the sun should not shine upon the needles, which eauses them to oseillate, or that any vibration should act upon them. Very delieate experiments are best performed during the stillness of night.
2. Aearus of Cross.
3. Aearus of Weekes.
4. Cylindrieal Eleetrifying Maehine.
5. Plate ditto.
6. Insulating Stool.
7. Head, shewing divergenee of hairs under tension.
8. Leyden Jar.
9. Ditto, with Lane's diseharging Eleetrometer.
10. Leyden Battery.
11. Henley's Quadrant Eleetrometer, for measuring amount of electricity of tension.
12. Armstrong's Hydro-Eleetrie Machine.
13. Thermo-Electric Battery.
14. Cruikshank's Battery.
15. Primary Coil, with soft iron eentre.
16. Baekhoffner's Electro-Magnetie Machine. By a modifieation of this, I obtain a single eurrent instead of a to-and-fro eurrent.
17. Horne and Thornthwaite's Electro-Galvanic Machine: z, zine of the battery; s, silver; A, screw to regulate the vibration of the maehine; B, watchspring vibration; C, water regulator; 1D, 2D, directors for applying the electricity.
18. Ditto ditto, with different lengths of seeondary wire, to adjust the power of the instrument.
19. Ditto ditto, arranged for the eonvenienee of packing.
20. A still larger maehine of similar class, with eontrivanees for removing the inclosed soft iron, whieh gives to the operator a still further power of regulating the amount of eleetrieity.
21. A Magneto-Eleetrie Machine.
22. Platinised Silver Battery in poreelain trough.
23. Sulphate of Copper Battery: z, zine; A. acid; s, solution of sulphate of eopper; P, porous pot.
24. Nitrie-Aeid Battery: A, acid; z, zine; P, porous pot; N, nitrie aeid.
25. Woollaston Battery.
26. Handles for the patient to hold during the applieation of eleetricity.
27. Radford's Conductor, for use in uterine inertion, amenorrhœa, ete.
28. Instrument for applying eleetrieity to the eye.
29. Ditto ditto ditto tooth. And the other portion to screw on for applying to the ear.
30. Flat Pole, oeeasionally used for the applieation of electricity.
31. Sponge, contrivance well adapted for applying eleetricity to the skin.
32. Pole, oeeasionally employed.
33. Ditto, for ineluding portions of the body.
34. Electrie Magnet: s s, binding screws; w, wire; B, plate of brass, eovering the soft iron.
35. Platinised Silver Pot Battery: s, silver; z, zine; B, binding serew; A. aeid; w, wood.
36. Magnetie needle.

PREFACE.

This little volume, however incomplete, and however unsatisfactory it may be found to the reader, has nevertheless cost me much time, labour, and thought. I have been for ten years engaged at intervals upon it; and its very slow advance, from year to year, has been a constant annoyance to myself.

The experiments, upon which this work is mainly founded, are of two kinds, physical and physiological. The physical experiments relate principally to the laws of voltaic electricity, and were, to a great extent, also required for my treatise on Electro-Metallurgy. To that work I must refer my readers for details, which it has not been considered necessary to repeat here.

I feel that an apology is due to the public, for having allowed the Elements of Electro-Metallurgy to be out of print so long; but press of business has prevented me from again directing my attention to the subject. Certain special investigations have been required in voltaic electricity, which have led to the consideration of hydro-voltaic, electro-, photo-, and thermo-voltaic circuits. Throughout this volume, I

have also referred to my "Sources of Physics," which was written expressly as an introduction to the present work three or four years ago.

The physiological matter required two lines of investigation; the one having reference to the ultimate structure of organic beings; the other, to the actions taking place in them. The anatomy of the part demanded very perfect modes of injection, and led to the employment of the carmine mixture, which, I have no hesitation in stating, is the most perfect and beautiful material for filling the capillaries of muscle and brain which has ever been discovered.

In examining the actions of the body by the electro-voltaic test, the mechanism of nervous actions has been determined. Besides these subjects, extensive experiments have been performed upon plants and various vegetable tissues.

These researches have occupied my time largely, and I will beg those who consider them imperfect or incomplete, to bear in mind that they have been performed in my own private dwelling, unaided by the advantages which public laboratories afford to their fortunate occupiers.

I am fully aware that the results of immediate research are esteemed in this country almost to the exclusion of deductions which may be made therefrom. Nevertheless, the higher parts of physiology must, in great measure, for ever depend upon deductions, and cannot be the result of immediate experiment. In this work, my attempt to deduce the physical structure of the brain has been found so difficult, that it could only

be prosecuted when I have been entirely removed from my ordinary business, and even then, the advance, year by year, has been exceedingly slight.

The study of the mechanism by which forces are generated in the body, has given rise to the artificial gymnotus, and to the formation of artificial muscular substance, the study of which appears to me to be interesting.

Having developed the voltaic mechanism of animal life, I considered that it would be advisable to study the electro-pathology of diseases, and the influence of electricity in their cure. Whilst, however, electricity appears to me to be an important agent for the cure of disease, the cases in which it is especially valuable are comparatively few; and I myself regard the treatment upon general electro-therapeutic laws as more valuable than the immediate action of electricity itself.

In submitting this volume to the Public, I regard it as a beginning of a subject, not as an end; as a commencement of the study of Physiology upon the laws of physics, which will require the united efforts of physiologists to render it more complete. It is a worthy subject for the talent of the country to be engaged upon, and nothing but the associated labours of many can render it of ultimate value.

My original intention was to have compared the labours of other investigators of the nervous system, and to have shewn the points in which former writings agree, and those in which they disagree; and also to have examined the various researches already

made by Philosophers on animal electricity. I found, however, that I had neither space nor time for this laborious undertaking, and I have therefore confined this work to the result of my own investigations and deductions.

During the progress of this volume, I have derived much assistance from my publishers, Messrs. Horne, Thornthwaite, and Wood, and other gentlemen, who have aided me in various ways. I have, however, especially to return my grateful acknowledgments to my kind and much-esteemed friend, Mr. John Beadnell to whom I am indebted for a revision of the proof-sheets.

7, Finsbury Circus,
24th February, 1849.

☞ *The printing of this Book was completed February 24th*, 1849.

ELECTRO-BIOLOGICAL MAP (No. 1).

BIO-TELEGRAPHS, PERIPHERAL SENSOR NERVES. BATTERY.

AISTHENICS.

Right Side.

ELECTROLYTE.

Eye
Ear
Nose
Tongue
Skin
Mechanism of Bodily Sensation.

POSITIVE.

Left Side.

ELECTROLYTE.

Eye
Ear
Nose
Tongue
Skin
Mechanism of Bodily Sensation.

POSITIVE.

CENTRAL BATTERY, OR BRAIN.

PHRENO-AISTHENICS.

Units of Sensation.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

Units of Sensation. **Commissure.** **Units of Sensation.**

Units of Sensation.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

SYNDRAMICS.

Combination of Units of Sensation.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

Combination of Units of Sensation. **Commissure.** **Combination of Units of Sensation.**

Combination of Units of Sensation.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

AISTHENIC-NOEMICS.

Totality of Combinations of each Sense.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

Totality of Combination of each Sense. **Commissure.** **Totality of Combinations of each Sense.**

Totality of Combinations of each Sense.

NEGATIVE
ELECTROLYTE.
POSITIVE.

SYNDRAMIC-NOEMICS.

Combination of Totality of each Sense.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

Combination of Totality of each Sense. **Commissure.** **Combination of Totality of each Sense.**

Combination of Totality of each Sense.

NEGATIVE.
ELECTROLYTE.
POSITIVE.

PNEUMA-NOEMICS.

Totality of Combinations of Totalities of each Sense and both Sides.

NEGATIVE.
ELECTROLYTE.

POSITIVE. POSITIVE.

BIO-TELEGRAPHS, MOTOR NERVES.

DYNAMICS.

PERIPHERAL BATTERY.

NEGATIVE.

Muscle.

ELECTROLYTE.

Right Side.

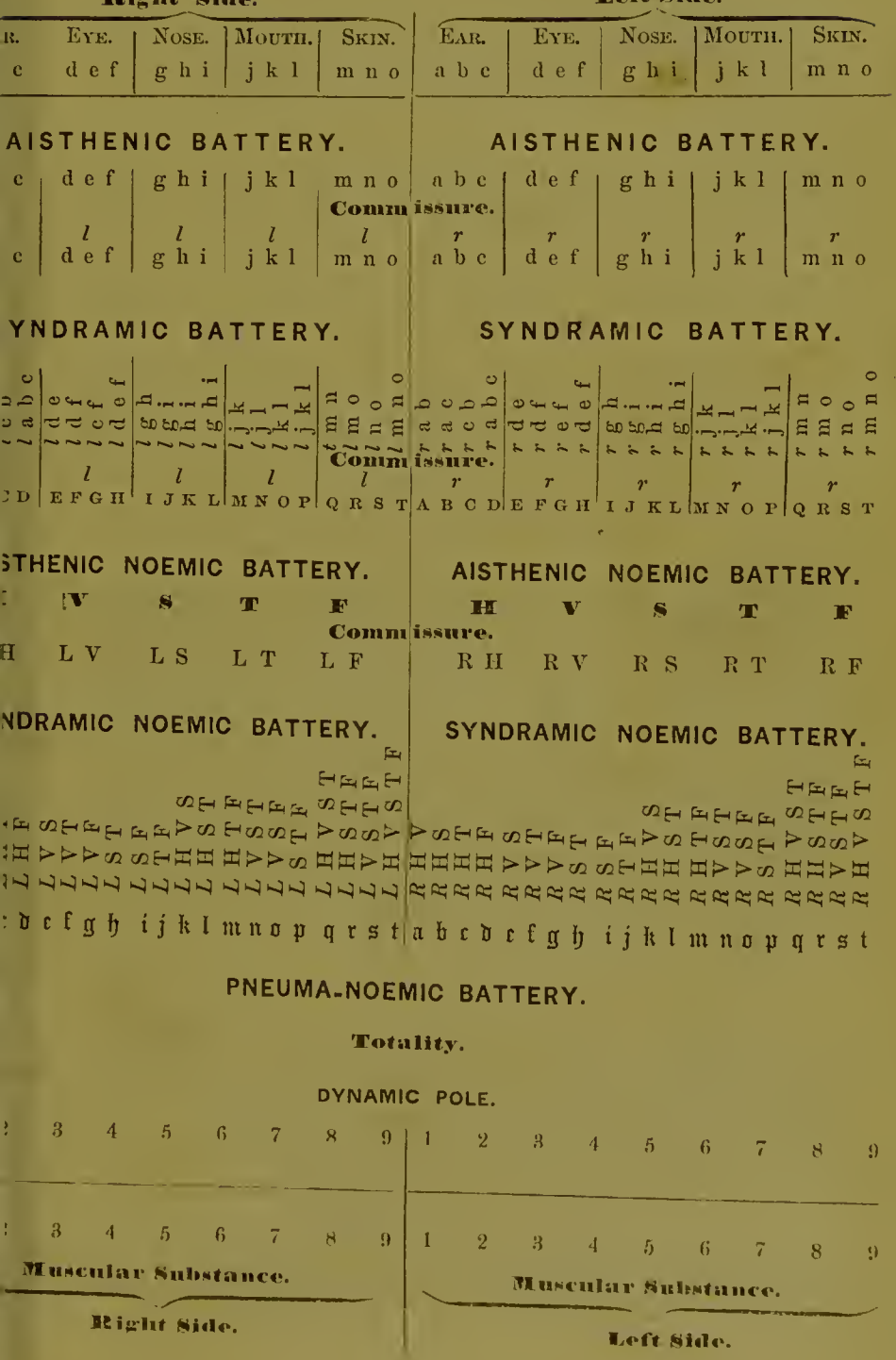
NEGATIVE

Muscle.

ELECTROLYTE.

Left Side.

ELECTRO-BIOLOGICAL MAP (No. 2).



ELECTRO-BIOLOGY;

OR,

THE VOLTAIC MECHANISM OF MAN.

CHAPTER FIRST.

ELECTRO-BIOLOGY.

1. Definition of Life.—2. Specific Actions of Life.—3. Organic Life.—4. Nerve.—5. Ganglia and Brain, General Functions of.—6. Nature of Life.—7, 8. Vital Phenomena purely Physical.—9. Immortality.—10. Requisites for Life.—11. Analogy between the Vital Apparatus and Voltaic Battery.—12. Extent of this Analogy.—13. Liebig's Arrangement.—14. Animal Battery.—15. Conditions necessary for.—16. Hydro-Voltaic Circuits; Induced Circuits.—17. Electro-Voltaic Circuit.—18. Current developed by Muscular Action; Experiment.—19. Deduction from.—20. Conditions for Experiment.—21. Peripheral Battery.—22. Structure of, in the Animal.—23. Central Battery.—24. Electro-Biological Circuit; Conditions necessary for.—25. Causes of Death; Electro-Biologically considered.—26. Sub-division of Biology.

(1). LIFE is a condition difficult to define, because it does not denote one constant state in the body to which it appertains, but refers to a series of changes continually occurring. The illustrious Bichât considers it to be "the sum of the functions by which death is resisted"; but this, to my mind, is not an intelligible definition. If we regard the state of a living animal, we find that it consists of two parts, a solid and a

fluid. Between these two parts changes are continually occurring. Life, therefore, comes under our notice only as an idea which we form of a solid and fluid body in a state of action, and thus may be defined to be—"The idea of the performance of certain specific actions between the parenchyma and blood or fluid of an organised being."

(2). The certain specific actions of life are those of growth, nutrition, and excretion, in certain cases, the generation of a particular temperature; in others, as in the glow-worm, of light; in others, as in the electric eel, of electricity. We observe sound to be produced in many organised beings; as, for instance, in the singing of birds; and, lastly, the power of generating force extends to a greater or less degree over the entire animal creation.

(3). Assimilation, growth, nutrition, excretion, and perhaps, the generation of a certain temperature, are common to all organised bodies, and may be termed the vegetable life; or, speaking more generally, the organic life—phenomena which in this work it is not my purpose to consider in detail.

(4). Besides the phenomena, classed together as the phenomena of organic life, there are yet others, which we find in the higher animals in great perfection, and which, by analogy, we may infer to belong to the lowest creature in the scale of creation. The phenomena to which I allude require for their manifestation, a more complex apparatus than that of the simple fluid and tissue to be found in all plants. We find that animals, to exhibit these phenomena, require a central parenchyma supplied with blood, a peripheral parenchyma supplied with blood, and a connection between the two, consisting of a peculiar tissue, called "Nerve-Fibre."

(5). The central parenchyma constitutes the ganglia of lower animals, the brain of higher. The peripheral parenchyma comprises the organs of sensation and motion. A proper supply of bright arterial blood to both situations is requisite for the manifestation of the phenomena of life. By this apparatus the

animal receives impressions from the external world, transmits them to the brain, registers them, combines them, and acts, not only on immediate impressions, but also upon those which it has received at former periods. These functions are termed the functions of animal life; and these alone will occupy our attention in the present volume.

(6). From the facts which I have already stated, we perceive that the vital functions are divided into two classes, those of animal life, and those of organic life; and to the idea of both collectively we assign the general term of vitality. Life, then, is one word used to signify a number of changes. It is no independent reality apart from the matter which exhibits these phenomena. Neither is it an imponderable attached to matter. Nor is it an all-pervading ether, or *anima mundi*, filling space, as some philosophers would have us suppose; but in its widest signification it is one word used to designate the combined functions of assimilation, growth, nutrition, excretion, the reception of impressions, the registration of impressions, the combination of impressions, together with the production of force, electricity, light, heat, sound, etc. Such is life, an idea necessarily inferring action, and realising the poet's thought,

"She dreads an instant pause, and lives but while she moves."

(7). In organised beings, therefore, the changes occurring in the organisation alone constitute the vital phenomena. Hence all animal beings, and even man himself, is solely constituted of matter, and obedient to physical laws. All phenomena of nutrition, growth, assimilation, excretion, together with the action of the senses, of memory, of thought, of reason, of action by word or deed, are phenomena produced by virtue of organisation, and consequently solely obedient to physical laws. ! ! !

(8). Whilst the dissecting-room reveals to us the structures

necessary for the organisation, the laboratory the composition of the respective parts undergoing change, universal science demonstrates that even proud man himself is not endowed with any imponderable, ether, or any other than a physical property for the purpose of manifesting any of those phenomena which are classed under the head of vital actions.

(9). Man, however, is immortal. Man at all times, and in all regions, has believed in his immortality. It is probable that this conviction has its origin in his very organisation. Now that which gives to man his immortality can have no relation with that which is mortal. Life, mind, thought, reason, knowledge, come from organisation and cease at death. "When the breath of man goeth forth, he shall turn again to his earth; and then all his thoughts perish."

(10). A central parenchyma, a peripheral parenchmya, connected together, and each supplied with bright arterial blood, are necessary to life. It follows, therefore, that bleeding causes death—that the supply of imperfect blood, such as carbonaceous blood, is insufficient to life. Moreover, a destruction of the central parenchyma, by injuring the brain, or of the peripheral, by destroying the body, instantly prevents the manifestations of the functions of animal life. Lastly, a separation between the central and peripheral parts, as in the act of pithing, is attended with the same result.

When action ensues, a change of matter occurs, which is proved by an increased excretion, and corresponding desire for food. This fact demonstrates that the functions of animal life are obedient to the general physical law, that no force can be generated without some corresponding equivalent change of matter.

(11). Putting all these facts together, we must seek for some physical apparatus which shall agree with the requisites for the maintenance of organic life. Now a central apparatus,

supplied with a peculiar fluid, a peripheral apparatus similarly supplied, the whole connected together to form one universal total, is the apparatus desired, and such an apparatus we have in a double voltaic battery.

$$\left\{ \begin{array}{l} Z \text{ —— } S \\ S \text{ —— } Z \end{array} \right\}$$

Now, if we abstract the proper exciting fluid from either end, or substitute any other fluid, or destroy the structure either at one end or the other, or divide the connecting portions or wires, the effects proper to the apparatus will not be manifested, and the battery will be destroyed.

(12). But the ordinary forms of voltaic battery would not answer to the physical mechanism of man. A human being contains no metallic plates, no metallic wires, but consists solely of animal membranes and fluids; and, therefore, we have to study voltaic batteries, solely composed of membranes and fluids, with connecting apparatus, the parts of which may be imitated by the materials naturally existing in the body.

(13). Liebig has already stated, that "Professor Buff has, at his request, constructed a pile, consisting of discs of pasteboard moistened with blood, of muscular substance (flesh), and of brain. This arrangement caused a very powerful deflection of the needle of the galvanometer, indicating a current in the direction of the blood to the muscle."

(14). Before the time of Liebig, Galvani had shewn that convulsions ensued in a limb, by simply bringing into connection the muscles and nerves. In the muscles we have a nitrogenised material which is acid; in the blood we have a nitrogenised material which is alkaline; and the connecting part or nervous fibres are neutral. We may imitate such a combination, by using a solution of ferrocyanate of potash, a compound of iron, nitrogen, carbon, and potash, with a little alkali for one side, a solution of the red ferrocyanate for the other side,

and connect the two with a solution of chloride of sodium, or common salt.

(15). If we regard the conditions necessary for a voltaic battery, we find that some body, either solid, fluid, or gaseous, in a state of adhesion, which has an affinity for oxygen, is required for the positive pole. Such a compound is the ferrocyanate of potash, and such a compound is the liquor sanguinis. For the negative pole, some highly oxygenated substance, or substance which easily parts with hydrogen, is required. This exists in the red ferrocyanate. This exists also in the red corpuscules of the blood, or perhaps in muscular fibre. These two parts must be connected together. In the natural circuits they are connected by the nerve; in the artificial by the chloride of sodium. I have at various times contrived many varieties of this form of circuits, which I propose to term Hydro-Voltaic Circuits.

(16). In the Hydro-Voltaic Circuits, we have a circuit similar to that generated in animals. No means, however, have heretofore been devised to indicate its presence in a single circuit. For many years I have felt this difficulty, and for a long time it seemed to me insurmountable, until the time of the prosecution of my electro-metallurgic experiments, when I observed the curious facts which I have detailed under the term of induced voltaic circuits. An induced voltaic, or electro-voltaic circuit, is a circuit which would not exhibit voltaic effects unless it were acted upon by electrical force; for instance, two iron wires in the same solution would cause no current: but if the two wires are situated in the path of another voltaic circuit, a secondary induced circuit is produced. In my Treatise on Electro-Metallurgy, I have shewn that even platina wires, with powerful currents of electricity, may exhibit the phenomenon, though the effect is far more readily apparent, when metals are employed which are competent to set in action electricity, but are simply in a condition unsuited for polarity.

(17). If we take two perfectly polished steel needles, and let them remain in any liquid for a short time, so that they may be under the same circumstances, they will exhibit no indications of electricity. When, however, a voltaic current acts upon the liquid, they immediately evince the properties of a voltaic circuit. The one near the negative pole of the battery will become positive; the other, near the positive pole, will become negative; and it is to this circuit that I shall have frequent occasion to make reference during this treatise, and which I propose to designate by the term of Electro-Voltaic.

(18). By employing the electro-voltaic circuit, we have a test by which we can ascertain the presence of a current in any hydro-voltaic combination, or supposed combination, even if it be limited to a single cell. Having thus obtained the mechanism for examining animal bodies, the time arrived for applying the test to the living creature. The first animal which was honoured was a black rabbit, into the masseter of which I introduced one sewing needle, whilst the second was placed in the subcutaneous cellular tissue. After leaving them for a few minutes, so that they might be in the same state, they were connected with the galvanometer, without sensible deflection of the needle. After a few moments, the animal not liking its treatment, made an attempt to bite my finger, and the deflection of the galvanometer instantly showed the mechanism of volition. I then gave the creature a piece of wood to bite, upon which it used all its power of mastication, and by catching the oscillation of the needle, a very powerful current was exhibited.

(19). In this experiment, the deflection of the needle in the electro-voltaic circuit proved the existence of a voltaic current passing through the parts during the action of biting; and did thus denote the mechanism of the force employed to throw the muscles into operation.

(20). My object in this work is rather to detail such results

as will induce others more fully to investigate the phenomena, than to attempt to enter minutely into each separate experiment. I may notice, that for the manifestation of the electro-voltaic current, the animal should be in good robust health, and muscular; however, during the experiment, the animal should be at its ease, and should rather exercise its powers voluntarily, than from irritants applied to the surface, though hereafter I shall have to point out that by pinching, or otherwise irritating, the same result may ensue. A feeble animal, or an animal under great fear exhibits the force but feebly. A powerful animal gives strong indications of the voltaic current when one needle is placed in the muscles of the back, the other under the skin.

(21). Inasmuch as the two needles are placed respectively in the skin and muscle of the animal, it follows that the current is greatest between those two parts, as the needle must be enclosed in the path of the current to exhibit the phenomena. The periphery or body, therefore, consists of the muscular substance, forming one pole, the cutaneous tissues the opposite, the serous fluid, which lubricates the parts, being the electrolyte. The whole forms a voltaic battery, which I shall hereafter consider in minute detail, as the Peripheral Battery.

(22). From the Peripheral Battery two series of connecting media proceed; the first, the muscular nerves, or nerves supplied to the flesh; the second, the nerves distributed to the cutaneous textures. If we examine the nerve-fibres in recently-killed animals, we find that they consist of fine tubes containing a fluid, and lined with a peculiar species of fat, which may be obtained from their prolongation into the brain in large quantities, when the part is soaked in alcohol for a long period. In this structure we have all the conditions necessary to insulation, namely, a fine membranous tube lined with fat on its inner side, and containing a fluid in the centre; and such a structure, as far as electrical properties are concerned, would be analogous to a glass tube containing liquid.

(23). If we follow the course of the nerves, we find that they are prolonged to the brain, and end in the gray matter, where they again come in contact with a large quantity of blood-vessels. As the two series of nerves are not immediately connected in the brain, it follows, according to the laws of voltaic action, that another battery exists there, which may be termed the central battery.

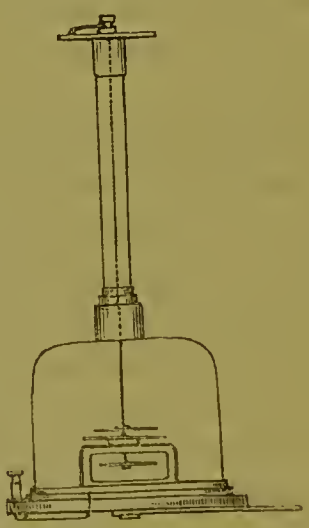
(24). For the continuance of animal life, it is necessary to have an integrity in the central and peripheral batteries; both requiring to be properly supplied with the normal exciting fluid, or blood. The poles of these respective batteries are connected by the nerves, to form one consistent whole, which I shall always hereafter mention under the term of Electro-biological circuit. For the integrity of this circuit, it is essential that the peripheral and central batteries be perfect, that their connection be maintained, and that a proper exciting fluid, or bright arterial blood, be distributed to each part.

(25). In taking a comprehensive view of Electro-Biology, we must also take a cursory glance at the different ways in which life may cease. Electro-Biology teaches that death may occur from causes emanating in the blood. For instance, when the blood is insufficient in quantity, it cannot perfectly carry on the vital actions; a state analogous to the voltaic battery insufficiently charged. Blood-death may also ensue when its quality is interfered with, as when the lungs do not perform their duties properly, or when the blood is altered by the action of poisons; and the sub-divisions of blood-death are probably very numerous. Death may also arise from destruction of the parenchyma, as when either the peripheral or central battery is crushed. If the connecting medium be severed, as in the act of pithing, death instantaneously ensues. Lastly, we observe forms of death not included in the above, in which the bio-dynamic actions are interfered with, such as death by exhaustion or collapse, analogous to an exhausted battery; and death by coma, where all the functions of animal life cease one after another; a result

which may be obtained in the battery, when any cause stops the continuance of the action.

(26). Electro-Biology presents itself to our notice in several departments. We have first to study the peripheral battery, the positive pole of which may be termed the "Aisthenic Pole," because it is destined to receive impressions from the external world. Following the course of the nervous fibres, we trace the effect to the central point, or brain, the study of which will constitute the second division of our subject, or Electro-Noemics. We shall then proceed to trace the operations of the bio-dynamic force to the muscles and other organs of force; and lastly, we shall study the changes which occur in the batteries, under the term of "Bio-Electrolysis."

FIG. 1.



ASTATIC GALVANOMETER.

CHAPTER SECOND.

ELECTRO-AISTHENICS.

27, Electro-Aisthenics defined. — 28. Subdivision of. — 29. Sexual sense. — 30. Conditions necessary for Sensation. — 31. Organs of Sensation. — 32. The Eye. — 33. Retina. — 34, 35. Its supply of Blood. — 36, 37. Photo-Voltaic Battery. — Experiment. — 38, 39. Voltaic Current attending Vision. 40. Difficulty of Experimenting. — 41. Positive Photo-Voltaic Current generated. — 42. Poles in. — 43, 44, 45. Estimation of Colour by the Eye. — 46, 47. Opsaisthenic Poles. — 48. Negative Pole, Conjecture. — 49. Cognisance of Vision. — Electro-Ousaisthenics. — 51. The Ear. — 52, 53. Estimation of Pitch and Direction of Sounds. — 54. Formation of Voltaic Circuit. — 55. Artificial Voltaic Ear, — Suggestion. — 56. Poles. — 57. Taste. — Electro-Gumaisthenics. — 58. Voltaic Current. — 59. Smell in the Lower Animals. — 60. Elaborate Mechanism. — 61. Requisites for Scent. — 62. Circuit demonstrated. — 63. How produced. — 64. Artificial Voltaic Nose. — 65. Poles. — 66. Cænaisthenics defined. — 67. How brought into operation. Thermo-Voltaic Batteries. — 68. Effect of Cold on the Sensor Nerves. — 69. Voltaic Action generated. — 70. Imitation of the Effect. — 71. Comparative Sensibility of Portions of Surface. — 72. Circuit demonstrated. — 73. Pacinian Corpuscula. — 74. Conclusion of Cænaisthenics. — 75. Somaisthenics described. — 76. Cognisance by bodily feeling. — 77. Estimation of Motion. — 78. Sensor Nerves. — 79. Voltaic Circuit.

(27). ELECTRO-AISTHENICS is that department of Electro-Biology, which treats of the mechanism by which man, and in fact animals generally, receive impressions from the external world, and are made cognisant of the changes occurring within their own bodies. This department of physiological research is so extensive, that volumes have been written upon this subject alone; but it is not my intention to extend the

bulk of this Treatise more than is absolutely necessary, as the work is rather destined to indicate to the labourer a road which he may follow, than to map it out with that certainty which I trust hereafter the subject will obtain.

(28.) Electro-Aisthenics, then, comprises the study of all the various organs of sensation, as that of sight, or Opsaisthenies—of hearing, or Ousaisthenics—of taste, or Gumaisthenies—of smell, Rinaisthenies—of touch, or Cænaisthenics. After a most attentive consideration of the subject, I feel that Biology must admit one other sense, namely that of bodily feeling, or Somaisthenies. By this sense we obtain a knowledge of ourselves, and of the changes taking place in different parts of our own bodies, without which, I shall hereafter shew, that we could have no individuality, no personality, and could not even perhaps prove that our bodies did not belong to another individual.

(29.) Besides these senses, some physiologists have considered the sexual feeling as referable to another sense; but if carefully examined, it appears rather to be the result of a combination of sensations, the first set being derived from without, from the opposite sex; and the second being derived from actions occurring within the body itself. Hence the sexual sense is a combination of Cænaisthenics and Somaisthenies.

(30). For the manifestation of the phenomena of all these senses, two conditions are invariably necessary—the presence of a nervous expanse, and the supply of bright arterial blood to that expanse. The universal co-existence of blood and nerve constitutes the foundation of Electro-Biology, for we invariably find that blood is useless without nerve—nerve inactive without blood—both being requisite for the production of any of the varied phenomena of animal life.

(31). We thus perceive that the mechanism of the various organs of sensation, differs not so much in kind as in organic arrangement, for the reception of impressions from specific

physical forces. The eye is destined to be acted upon by an illuminated body or light; the ear by sound; the nose by odours; the palate by tastes; the skin by heat, cold or force; and the mechanism of bodily sensation by the changes taking place within our own bodies. In consequence of the mechanism of these various organs being different, it will be necessary to give a brief description of each separately.

ELECTRO-OPSAISTHENICS.

(32). I commenced my enquiries upon the mechanism of the senses with investigating the structure of the eye, because it is admitted by mankind to be the most important organ of sensation which human beings possess.

(33). In my treatise on Vision, I have considered the various phenomena in minute detail; and therefore in this work I shall confine my attention to the cause of vision. For the manifestation of this phenomenon there are two requisites; the presence of arterial blood, and the integrity of the retina. The retina is an expansion of the optic nerve, which penetrates the globe of the eye and forms a layer which has various degrees of sensibility, as the central part alone is adapted for the most perfect vision, the lateral portions being only capable of appreciating the general presence of objects. Vesicles, similar to those found in the brain, are connected with the retina; and in these spots it has been thought the action occurs.

(34). With regard to the supply of blood, we have to look to two sources; for we find arterial blood in the arteria centralis retinæ, and in the innumerable vessels of the choroid coat. The first artery is a delicate artery, running with its corresponding vein over the surface of the retina, or that part in contact with the vitreous body. There appears to me to be good ground for supposing that the artery is destined for the

nutrition of the vitreous body; and in fact it is much too small for the changes which constitute the act of vision.

(35). Besides this delicate vascular layer, there is another part highly charged with bloodvessels; and their wonderful ramifications are so beautiful and intricate, as to attract the attention and excite the amazement of the most casual observer. This vascular layer is called the choroid coat, and perhaps really constitutes the blood necessary to the retina, for various reasons. The vessels of this tunic are so arranged that the arterial trunks are situated near the retina, the veins behind, and out of the way; and, moreover, the capillaries are brought into contact with the retina; the larger branches being placed posteriorly. Furthermore, in the axis of the eye, where vision is most distinct, there this structure is found to be the most beautiful and intricate, and at that very precise spot the so called artery of the retina does not exist, but is so arranged as not to interfere or come in contact with it. I have prepared exquisite injections of both the retina and choroid, and a study of their characteristics forbids the idea that the artery of the retina would be sufficient to furnish the blood essential for vision.

(36). Blood and nerve being present, we have to observe in what manner action can be excited; and we find that the usual stimulus to the eye is light. The question now naturally arises whether it be possible to make a Photo-Voltaic battery. In the chapter on Electro-Biology, I explained that the conjunction of blood and nerve was probably equivalent to a material having an affinity for oxygen, placed in contact with a highly oxygenated solution. To imitate this condition, I placed the undermentioned solutions in a glass vessel, and inserted also into it two platinum poles, the one covered over with an opaque vessel* so that it might be in darkness; the other uncovered, that it might be freely exposed to the light of the sun.

* The bowl of a tobacco pipe inverted is found to be convenient for the purpose.

1.	Mixed Solutions of	Proto-sulphate of Iron and Nitrate of Silver.		
2.	Do. do.	Gallic-acid and Nitrate of Silver.		
3.	Do. do.	Oxalic-acid and Chloride of Gold.		
4.	Do. do.	Ferrocyanate of Potash and Ammonia		Per-citrate of Iron.
5.	Do. do.	do.	do.	Tartrate of Iron.
6.	Do. do.	do.	do.	Potassio-Tartrate of Iron.

Upon exposing the apparatus to intense light, the galvanometer was instantly deflected, shewing that the light had set in motion a voltaic current, which I propose to call a photo-voltaic circuit. In these instances, the platinum exposed to light, acted as the negative pole of a battery; and therefore this series I term negative photo-voltaic circuits. By using other solutions, for instance, those of per-nitrate of iron and red ferro-cyanate of potash, or of mixtures of Bromine water, phosphorus water, and per-nitrate of iron, a photo-voltaic circuit is generated in an opposite direction, and therefore I have designated them positive photo-voltaic circuit. In the negative photo-voltaic series there appears to be a tendency to the reduction of metals, which may be regarded as equivalent to the evolution of Hydrogen. In the positive series oxygen is evolved, which causes the current to act in the opposite direction.

(37). In the above experiments, it is manifest that the eye would present no extraordinary phenomena if it were a voltaic circuit where action was determined by the influence of light, as such a mechanism would be in conformity with ordinary physical phenomena, and obedient to ordinary physical laws. The question, however, is now to be decided, whether there is or is not a photo-voltaic circuit generated where vision occurs; and for the purpose of determining this point we must have recourse to the test which I have already, in the chapter on Electro-Biology, described under the term of an Electro-Voltaic Circuit.

(38). To apply this test to the eye, one needle should be thrust into the eye of an animal through the choroid coat; and

a second into the muscle in the neighbourhood; when if a sudden transition be made from darkness to strong light, a very slight deflection of the galvanometer declares the presence of a photo-voltaic current.

(39). There are unquestionably considerable difficulties in the operation; but by careful management and watching the oscillation of the needle, the current may be made decidedly appreciable. In estimating these effects, two tests are applicable; first, the motion of the needle in one direction; and secondly, the stopping of the oscillation of the needle when the current is reversed. A very feeble current may be ascertained with certainty by this manœuvre.

(40). In detailing the results of these experiments, I think it right to state that I have relied upon a multitude of trials. Sometimes I have utterly failed to produce any effect; at other times, I have been dissatisfied with my results; and it is only occasionally, when I have been fortunate enough to get an animal at his ease and in so little fear that he would be happy and comfortable during so unpleasant an operation, that I have succeeded in obtaining satisfactory results. It is a curious circumstance, that in no instance have I ever seen any permanent injury inflicted on an animal from this mode of treatment. I have caught strong, healthy cats, and subjected them to similar experiments, but they generally have been in such a terrible fright, from the confinement necessary to keep them quiet, that I could make no use of them for Electro-Biology.

(41). A positive photo-voltaic circuit is generated in the eye; that is to say, that the needle in the eye deflects the galvanometer in the same direction as though it were placed near the negative pole of the battery, and consequently would have the opposite condition induced in it.

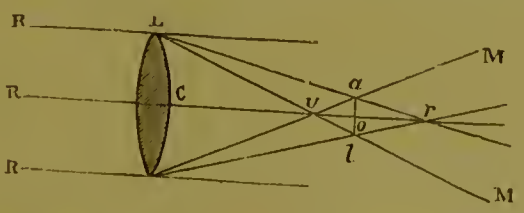
(42). Having found that the retina and blood of the choroid coat constitute one pole of the opsaisthenic battery, it is left for us to consider the position of the second; and I may state, that the nervous filaments supplied to the muscular structure

of the eye-ball and eye-lids form the opposite pole. In treating of Electro-Biology, I explained how each nervous fibril of one pole was opposed to a number of nervous fibrils in the other pole; and therefore it need not occupy our attention again at this place.

(43). It is an uncertain point, upon which Physiologists are not agreed, as to the means by which the mechanism of the eye enables us to estimate colour; that is to say, we do not know whether the three colours are carried as three separate impressions to the brain, or whether the three impressions are carried by one nerve to the brain, and are there analysed into their component parts.

(44). The phenomena of colour must depend upon a difference of action produced upon the retina by the three primary colours, of which Brewster has shewn the sum total of the spectrum to consist. Now, it has been demonstrated by Sir John Herschel and other observers, that the different colours have a diversity of powers to produce chemical changes; therefore it must follow that, by the three colours—red, yellow, blue,—a different intensity of action would arise. We thus find that in the perfection of nature's works, it would be within the range of physical laws to have photo-voltaic circuits which should only be excited by the respective coloured rays.

(45). As the three primary colours have different degrees of refrangibility, any arrangement by which the retina was made to consist of three layers, would enable us to have the most perfect estimate of colours—a proposition which may be understood by the next diagram. The red rays would collect at *r*, the violet at *v*. From this circumstance, we may be led to infer



that the retina has a certain depth, in the parts of which each

specific colour is brought to a focus. Such a contrivance will manifestly be the most perfect that could possibly be adopted.

(46). The extent of the retina which is serviceable for perfect vision, does not certainly exceed the 1-30th of an inch in diameter; for I find, by actual measurement, that it scarcely amounts to one-third of the insensible spot caused by the puncture of the optic nerve. I must refer my reader, for specific details upon these points, to my "Lectures on Vision," where my experiments are fully detailed. Now, if we could only tell how many points of definite magnitude we could observe at one time, we should be enabled to decide the number of opsaisthenic poles which exist in that part of the eye; but, at present, I have not succeeded in learning the fact.

(47). The essential structure of the eye consists in a definite number of distinct poles of the electro-biological batteries; and according as they are influenced by illuminated images, an action would occur in a sort of pattern, similar to that used by ladies for the designs of worsted work. At this point light loses its physical characters, and becomes aisthenic by its determining a voltaic circuit which acts upon the brain and gives a knowledge of the external world.

(48). Hitherto, we have only studied *one* pole of the opsaisthenic battery, and we have seen the aisthenic pole to be the retina and choroid. Upon the manner, however, in which the circuit is completed, I wish to speak with extreme diffidence, and wish Electro-Biologists to investigate it further. It is possible that the negative pole may be at the iris, as we find that the movements of the structure are regulated by the amount of action of the retina. It is also possible that the negative pole may not only be at the iris, but at all the muscles of the eye-ball and eye-lid, and even of other parts.

(49). When the faculty of vision is exercised, there is also a knowledge carried to the brain that a certain change has occurred in the eye, which is the bodily feeling,—a phenomenon which I consider more in detail hereafter, under the term of *Somaisthenics*.

(50). The mechanism by which we arrive at a knowledge of sound is not so well understood as that by which we are made acquainted with light; and, in fact, experiment cannot be brought to bear for the demonstration of its true and essential nature. However, all Physiologists are agreed, that the *seventh* nerve is the nerve which is acted upon by the impressions of sound, and this nerve is distributed to certain parts where we may infer, by analogy, that the ousaisthenic pole is situated.

(51). Sound is collected by the external ear, and inpinges upon the membrane of the tympanum, which is thereby thrown into vibrations. From this membrane it is continued to the inner ear, partly through a series of bones, and partly through the air. The inner ear, to which the ousaisthenic or auditory nerve is distributed, comprises three semi-circular canals, and a curious structure called the cochlea. To these parts, the blood-vessels and nerves are distributed. Without entering into long disquisitions on probable or possible modes of action, we may assume that the arrangement is of such a character as is suitable to allow the vibrations, according to the pitch, to act upon particular nerves; or, according to the direction from whence the sound originates, to influence particular localities.

(52). According to this view of the structure of the ear, the cochlea would be in reality one long, extended membrane, consisting of a number of nervous terminations, or ousaisthenic poles. The pitch of notes is probably determined by the cochlea; and therefore, if we could determine the length of the nervous membrane supplied to it, and ascertain the limits of hearing in that particular individual,—or, in other words, the highest and lowest notes which he could distinguish,—moreover, if we were acquainted with the minuteness with which he could distinguish different sounds, that is, whether the individual could determine variations of the eighth or the sixteenth of a tone, then we should be enabled to calculate the size and number of the ousaisthenic poles which give to man his ideas of pitch: for, according to the view which I have here given,

each specific sound of appreciable pitch has a certain specific and invariable locality in the cochleal membrane.

(53). The range of sounds appreciated by the human ear, consists of about 12½ octaves, and perhaps extends to the 32nd of a note, in those endowed with most perfect hearing. From this it follows, that the human ear can distinguish about 3,200 sounds; and therefore it would require 3,200 poles for that purpose. The means by which we distinguish the direction of sound appear to be more obscure, but probably they are learnt by various combinations of impressions in the semi-circular canals which are placed in the three dimensions of a cube, or, to use the geometrical phrase, in the three orthogonal planes of a cube.

(54). At first sight there certainly does appear much difficulty in constructing a voltaic circuit, which shall be acted upon by the vibration of sound. Upon consideration, however, that difficulty will not be found to be so great, for as the internal ear is enclosed in a solid unwieldy case, it follows that the part on which a vibration impinges, will have the delicate capillaries emptied of blood. From this result, according to the Bio-Electrolytic law, the oxygenated corpuscules would not be present at the termination of the nerve, and a voltaic circuit must of necessity be formed.

(55). We may merely, in a remote and imperfect manner, imitate such a state of things, and form an artificial ear, by fixing a piece of vellum over a glass vessel shaped like a funnel, and terminating in an inverted syphon. When the vellum is thrown into action, the water would be displaced in the tube, and as a consequence thereof, a circuit might be made or broken. By labour, I have no doubt but that a perfect acoustic telegraph could be made, which shall be acted upon by sounds, and have the power of transmitting them to any distance.

(56). The Ousaisthenic pole, or auditory nerve, has alone at present occupied our attention, and in all probability it

would be the positive pole. For the pole opposed to this, perhaps we may look to the muscles of the ear, or of other parts. Lastly, we must estimate the bodily feeling of hearing, namely, the amount or the intensity of sound, a phenomenon hereafter to be further considered.

ELECTRO-GUMAISTHENICS.

(57). Man is made but little acquainted with the external world by the organ of taste, although there is no reason to doubt that the mechanism of this sense corresponds with that of other departments of Electro-Aisthenics. Blood and nerve are both necessary for the manifestation of the phenomenon; and, reasoning by analogy, we may assume that the termination of the gustatory nerve forms the positive pole, though my direct experiments upon this point have been by no means satisfactory.

(58). We may make a voltaic battery, in which the circuit shall be determined by savours, in very different methods. For instance, if we place a little per-salt of iron, with two platina poles, in a **V** shaped tube, and then drop a little infusion of meat into one side, a voltaic circuit will instantly be produced. In nature, taste is probably excited by the absorption or contact of savours.

ELECTRO-RHINAISTHENICS.

(59). The human being can probably never become much acquainted with the nature of the various impressions which are obtained by animals through the medium of the nasal organ, because in man the sense of smelling is exceedingly imperfect.

(60). When we observe, however, the elaborate mechanism

of the turbinated bones of the cat, dog, and other creatures, the Electro-Biologist must admit, that such exquisitely complicated structures could not have been made in vain. The hound, which follows the hare for miles simply by the odour exhaled by its touch, possesses a sense of which man can form but little conception. Of the properties of odours we know but little; and whilst in some instances they depend upon material exhalations, in others they would rather seem to act as a mere force, and would justify a hypothesis of vibrations, a question which I have more particularly considered in my "Sources of Physics."

(61). Blood and nerve are necessary for scent. The olfactory nerve is distributed to the turbinated bones, and a most intricate layer of capillaries runs in the same situation to furnish a proper supply of arterial blood.

(62). To examine the mechanism of the nose experimentally, a needle should be thrust up the nasal organ,—an operation to which most animals have an extreme repugnance. The other needle should be inserted in the textures about the alæ nasi, and the scent may be excited by a little hydro-sulphuret of ammonia. The result of this experiment is often masked by secretions which interfere with the result; but, in good instances, the galvanic needle will be deflected as though the nose were the positive pole of the battery.

(63). The *modus operandi* of odours, in determining the circuit, is obscure, though the operation of hydro-carbons, camphor, oil of turpentine, sulphuretted hydrogen, and bi-sulphuret of carbon, may possibly be explained upon ordinary voltaic hypothesis; for, if we only suppose that they facilitate the reduction of the highly oxygenated blood, the voltaic current must be propelled to act.

(64). An artificial nose may very easily be formed to act with certain odours, such as ammonia; for, if we place two pieces of iron in a tube divided by a diaphragm to imitate a nose, and place each piece in contact with very dilute muriatic

acid, no current will arise. If to one pole, however, the fumes of ammonia be applied, polarity will be produced, and a voltaic circuit generated.

(65). The olfactory nerves would form the positive pole of the battery, and it must remain a matter of uncertainty to determine the exact position of the opposite pole, though in all probability the muscular structures of the alæ and face usually perform that function.

(66). The bodily sensation of the sense of smelling must also be considered in connection with the other phenomena; but that will be studied in a subsequent part of this chapter.

ELECTRO-CÆNAISTHENICS.

(67). The sense of feeling, properly so called, is much more circumscribed than it at first sight appears, because it is confounded with another sense which I shall describe hereafter, under the term of "Somaisthenics," or bodily feeling. The cænaisthesis is that feeling by which we derive certain impressions from without, and is never in our understandings confounded with a bodily feeling, or that sense by which we estimate the changes taking place within our own frame.

(68). Cænaisthesis is brought into action by the application of heat or cold; it is also brought into action by pressure, or other mechanical force. It is a perfectly simple and ordinary physical phenomenon for a voltaic circuit to be excited by temperature, a variety of battery to which I have assigned the term of a "Thermo-voltaic Battery." This form of circuit is of two kinds, positive and negative. In the positive thermo-voltaic circuit, the current is generated at the positive pole by the increase of temperature facilitating the chemical action; thus, if two pieces of iron wire be inserted in a **V** shaped tube containing water, with a trace of sulphuric acid, and one leg

be exposed to the action of heat, the current will start from that point. In negative thermo-voltaic circuits, the heat produces such actions as to cause the current to start from the cooler part of the solution. The nature of these currents is so obvious when once explained, and so diversified, that I need hardly occupy the attention of experimenters further than to state, that I have observed at different times a large number of thermo-voltaic circuits.

(69). In the living body, cold probably acts upon the sensor nerves to determine the voltaic circuit, by diminishing the circulation in the capillaries; and any mode by which the supply of arterial blood would be interfered with, would cause the circulation of the voltaic force. Excess of cold ultimately stops action, as repair could not follow the consequent exhaustion.

(70). There is no difficulty in the consideration of a voltaic circuit excited by force; for if by pressure we prevent the arterial corpuscule from coming in contact with the nerve-fibre, action must arise, inasmuch as the balance would be destroyed, polarity would ensue, and action would take place.

(71). We may imitate this kind of circuit by very easy means. For instance, if we take two pieces of iron wire, and insert them in very dilute acid, no action ensues, when tested by the galvanometer. The same result is obtained if the blood corpuscule be imitated by taking a membrane containing a little nitrate of iron, and placing one such artificial corpuscule against such iron wire. As soon, however, as the artificial corpuscule is thrust aside from the pole, a very powerful current is generated, which has its origin at that pole where no corpuscule exists. This structure is strictly and perfectly analogous to the natural mechanism of the body.

(72). All parts of the surface of the body are eminently endued with blood-vessels to carry the blood necessary to cænaisthesis. The sentient nerves, which are regarded as the aisthenic pole, are distributed close to this situation. Feeling,

however, is not equally acute in all regions; the lips, the tops of the fingers and toes, and some other parts being far more highly endued with sensibility than other portions of the body. This difference of sensibility exhibits itself in two ways; either a less amount of heat or force may cause feeling; or a smaller amount of both may have the same effect, which latter property is owing to a less frequent distribution of the ultimate nerve fibres, and consequent less numerous aisthenic poles.

(73). The determination of the course of the voltaic current is extremely easy, if the cænaisthesis is the subject of experiment. We have only to introduce one needle into the muscular tissue, and a second under the cutaneous structure, when a distinct current is immediately manifested in the galvanometer, when the animal is pinched or otherwise irritated. From this experiment we learn that the cænaisthenic pole is positive—the muscle, negative. Of course, the electro-voltaic current, by which we render manifest this phenomenon, is in the reverse direction.

(74). The animals which I have found best adapted to these experiments, are rabbits, for they are usually so tame as not to be incommoded by our operations. The eel also answers well, and exhibits the effects when it is either pinched or irritated.

(75). Blood and nerve are requisite for cænaisthesis, but the precise mechanism is still but imperfectly understood. Within the last few years, curious structures have been discovered over the whole course of the sensor nerves, which have been termed the Pacinian corpuscules. These singular appendages contain both artery and nerve, and consequently possess all the requisites for one pole of the battery; and there is a fair probability in the assumption that they are really the true aisthenic poles, or positive poles of the peripheral battery.

(76). Having concluded the mechanism of cænaisthesis, I have now described all the means by which man is made

acquainted with the external world, namely, by the specific organisations of the eye, the ear, the nose, the mouth, and the skin. All these organs agree in constituting the positive pole of the great peripheral battery of the Electro-biological circuit.

ELECTRO-SOMAISTHENICS.

(77). Man, however, is not only acquainted with the external world through the medium of the senses already described, but he also knows, to a certain extent, the changes which are taking place in his own body; a knowledge of the very utmost importance, in estimating the human powers. This power I shall here describe under the term, "Somaisthenics," which means nothing more nor less than bodily feeling; and under that term we shall study the mechanism by which we estimate our bodily changes.

(78). By Somaisthesis we appreciate the most minute muscular movement, for we cannot move any muscle even to the slightest extent without being conscious of it; and this knowledge of the extent of motion gives us a multitude of ideas. In my treatise on Vision, I have shown that our knowledge of distance, of magnitude, of form, and of many other phenomena, depends upon an exact appreciation of the movements of the muscles which direct the eye-ball. We obtain a somewhat similar knowledge by an estimate of the movements of the hand; and it is remarkable to what extent we obtain knowledge by an intimate acquaintance with minute muscular movements. The sense of touch is derived principally from a knowledge of these minute changes.

(79). In my work on Vision before quoted, I have hazarded a conjecture that this sense of motion is derived from the motor nerves; but subsequent experiments and observations have

tended to shew that this sense depends upon the sensor nerves; and that, therefore, when the mechanism of motion is, comparatively speaking, perfect, no sense of the amount of motion exists while feeling is defective.

(80). The mechanism of Somaisthesis is not very plain, though I have ascertained that it does not exist when injury has been inflicted on the cutaneous tissues in a situation where the nerves of feeling are distributed. I know a gentleman who has sustained an injury in one finger, which has more or less impaired the sensation of the part to external influences. In his case he is also unable to judge of muscular power employed in the deflection of that finger, shewing that although the muscle is at a long distance from the sensor nerve, yet this latter carries the idea to the brain.

(81). It must remain a question for further consideration, whether a separate set of nerves are required for bodily feeling, or whether this function is performed by the cænaisthenic nerves. It is manifest that no difficulty surrounds the consideration of the voltaic mechanism of the somaisthenic pole; for as we can have no motion without force acting upon certain parts, it is certain that this force might prevent the arterial blood from coming in conjunction with the nerve, and thus a circuit would be generated.

CHAPTER THIRD.

ELECTRO-NOEMICS.

VOLTAIC MECHANISM OF THE BRAIN.

82. Central Battery or Brain.—83. Connection with Peripheral Battery.—84. Syndramics.—85. Aisthenic Noemics: Syndramic Noemics.—86. Pneuma Noemics.—87. Noemic Syndramics.—88. Complexity of the subject.—89. Brain, its Muscular and Nervous Structure.—90. Injected preparations.—91. Memory.—92 and 93. Illustrated voltaically.—94. Activity or Passiveness of Mental Functions.—95. Repetition of Peripheral Battery in the Brain.—96. Terminations of the Aisthenic Nerves in the Brain.—97. Negative Pole of Noemic Battery.—98. Repetition voltaically shewn.—99. Brain, a Double Organ.—100. Commissures.—101. Voltaic Imitation of.—102. Cells in the Gray Matter.—103. Syndramics.—104. Elaborate Structure of Brain.—105. Syndramic Battery: Poles.—106. Voltaic Imitation.—107 and 108. Intercommunication of Fibres.—109 and 110. Commissures, Corpus Callosum Cerebellum, Cerebrum, Olfactory Ganglia.—111. Aisthenic Noemics.—112. Poles.—113. Syndramic Noemics Defined.—114. Pneumo-Noemic Battery.—115. Defined; its Poles.—116. Its Situation in the Brain.—117. Desire a Voltaic Phenomena.—118. Regulating Laws.—119. Modus Operandi of Batteries throughout; Extreme Action of Pneumo-Noemic Battery.—120. Idea of Space.—121. Idea of Time.—122. Sensation of Pleasure.—123. Pain.—124. Effect of Extreme Impressions: voltaic Illustration.

(82). Having considered the mechanism of the aisthenic part or positive pole of the peripheral battery, we are led, in the natural order of events, to study the changes which take place in the central battery or brain

(83). Each sensor or aisthenic nerve terminates in the vascular tissue or gray matter, from which, and other reasons, we may infer that the peripheral battery is simply repeated in the

central. This repetition of impressions in the brain may be called phreno-aisthenics.

(84). But as man receives ordinarily many impressions at the same time, and as he clearly remembers combined impressions, it will be necessary to assume a second structure, in which these combinations occur, which part of the subject I term Syndramics.

(85). Further, the sum total of the impressions of each separate sense gives us but one idea, such as that of sight, from all things we see; of hearing, from all things we hear. It follows that we must possess a mechanism capable of affording this, which structure I shall consider under the term of Aisthenic-Noemics.

We, moreover, have ideas which we derive from combined senses, the study of the structure of which I have termed Syndramic-Noemics.

(86). In the human being, we must have some structure from which we derive our notions of infinity; and to the consideration of this I have assigned the term of Pneuma-Noemics.

(87). Lastly, we have to consider from whence the impulse is sent for the brain to cause action; a study which may be conveniently followed under the term of Noemic-Dynamics.

(88). The mechanism which we have to consider is, therefore, abundantly complex; because, an impression communicated to any aisthenic filament would, as a general proposition, at certain times, excite any dynamic nerve in the body to action. The details are therefore exceedingly difficult to comprehend in all their minutiæ; and yet I trust, by passing gradually from the simple to the complex, the leading features of this wonderful and intricate apparatus will be developed: and though the exemplification of the structure of a single brain would occupy many acres, I can exhibit examples of the mode of acting in the several departments by ordinary voltaic combinations, which I shall hereafter describe.

(89). The requisites of action, blood and nerve, are found in sufficient abundance in the central battery or brain, as that

organ is literally nothing but fibres and blood-vessels. The nervous fibres are so numerous, that no estimation could be given of the myriads of which the brain is composed; in fact, the whole of the white matter of the brain is composed of nerve tubes. The blood-vessels are distributed to the gray matter in all parts of the brain, which presents a truly wonderful example of vascular structure when perfectly injected.

(90). I have been enabled to make the most beautiful injections of the brain and spinal marrow which have ever been executed, by using an injection consisting of carmine dissolved in ammonia, and mixed with a solution of isinglass. This injection is of an intense colour, perfectly fluid, and is thus enabled to penetrate the minutest ramifications of the capillary vessels. In injecting the brain, it is necessary to use one that is perfectly fresh; and I generally inject immediately after the animal is killed. By these means the most exquisite injections of the brain and spinal chord have been executed; and in all my preparations it is shewn, that wherever gray matter exists the blood is distributed, and where the white matter exists there is no blood; and from these considerations, physiologists infer that the gray matter is the active part of the brain.

ELECTRO-PNEMONICS.

MEMORY A VOLTAIC PHENOMENON.

(91). When a man receives an impression, it is not evanescent, passing immediately away, but it is retained in the system to regulate future actions. Now, in voltaic constructions, it is not difficult to produce an action which shall influence future motions, and thus exhibit the effects of memory.

(92). If we take two iron wires, and place them in a solu-

tion of argento-cyanide of potassium, and direct a voltaic current through them, silver would be reduced at that wire constituting the negative pole. The two wires would be ever afterwards in different electric relations to each other; one would be positive, the other negative; and thus the effects of memory would be shewn, and future actions regulated.

(93). I think it quite superfluous in this work, to give a multiplicity of instances of a similar character; otherwise, I could record a multitude of cases in which changes are produced at the poles, or upon the fluid which should give a persistant effect and exhibit all the properties of memory, which is well known to all pathologists to be entirely a physical phenomenon arising from some change taking place in the sensorium itself, and which is influenced by all causes interfering with the action of the brain.

(94). Now a question arises as to whether electro-pnemonics is an active or a passive property—for we may have either in a voltaic combination. We may have a passive result of memory, where the facility of the passage of electricity is interfered with, as where an ordinary battery is surcharged with sulphate of zinc. We may have an *active* memory, as in the first experiment detailed, or when any circumstance is produced competent to effect a persistant polarity. As, however, the most acute observers agree in assigning a spontaneity or activity to thought, we may infer that where the electro-noemic batteries are thrown into action, an impression arises which, at some future time, may produce results according to laws hereafter to be detailed.

PHRENO-AISTHENICS.

THE RECEPTION OF UNITS OF SENSATION.

(95). The mechanism of the peripheral battery is repeated

in the central; that is to say, for every active point in the body, an active point exists in the brain. For the locality where each action is repeated in the brain, we must have recourse to anatomy, and must trace each separate filament to its termination in the gray matter; and we find that the cænaisthenic nerves emanating from the spinal marrow are prolonged into the cerebellum. From this fact, it would be apparent that a division of the peduncles of the cerebellum on one side, would determine a motion towards the opposite,—a fact which actually occurs in nature: for of all the singular physiological effects which can be produced, there is none more remarkable than the continued revolution of an animal thus injured.

(96). The phreno-telegraphs or nerves of the nose terminate in the olfactory lobe, which is enormously larger in animals than in man. The optic nerves pass to the *corpus geniculatum externum* and *internum:* those of the ear, to the *calamus scriptorius.* Much, however, as the labours of modern anatomists have done to increase our knowledge of the structure of the brain, the exact situations at which each aisthenic nerve, or even of each class of nerves, terminate, is by no means certain.

(97). All the nervous fibres terminate in the vesicles of the gray matter, and thus come in contact with the blood-vessels, where they would form one pole of the noemic battery. As this pole alternates with the aisthenic, or sensor pole of the body, which we have already found to be positive, the laws of electricity teach that this pole would be negative; but probably it will for ever be impossible to devise any experiment which shall directly determine the point in the body itself.

(98). An analogical arrangement may easily be found in voltaic experiments, where the actions of one battery are repeated in the second; for instance, if we take an ordinary battery, and attach it to a precipitating trough, similar to that employed for the reduction of metals in electro-metallurgic experiments, the latter cannot act without the former; and when the former is thrown into action, an action precisely

equivalent takes place in the other. The electrical resistance produced by such a combination may be extremely slight.

(99). The entire body, then, is first repeated in the brain, nerve for nerve, action for action; and in this way we obtain the idea of units of sensation. In the perfection of nature, we may assume that each pole equally conduces to the production of mental phenomena. I have already mentioned at the commencement of this chapter, that there are strong reasons to suppose the brain is a double organ, and moreover, that two impressions, one received on each side of the body, give but one idea to the mind. To preserve this doubleness of the apparatus, that is to say, to have the actions in duplicate, each fibre must be connected with the corresponding fibre in the opposite side of the body. From these considerations, I apprehend that the second pole of the phreno-aisthenic battery, which would be positive in its electrical arrangements, is used for these commissural purposes.

(100). By this communication, two distinct systems of apparatus are formed, of which one is but the duplicate of the other, so that any action taking place on one side would be manifested on both. This connection is doubtless effected in the brain by the so-called commissures, though much labour is still required to be bestowed by the anatomist to follow out the fibres of each respective sense. The mode of arrangement appears to vary in certain parts; for in some cases, as in vision, a very peculiar contrivance is found in the commissure of the optic nerve. Here, the two inner portions probably divide, and one part continues its own course, while the other passes to its neighbour. In this way, the sum total of the field of vision will be represented on each side of the brain.

(101). The commissure, which we may, for anatomical considerations, reasonably expect to exist in the human brain, may be readily imitated in voltaic arrangements; for if we connect together the negative plates of two decomposition troughs, which are excited each by its own separate voltaic battery,

the same result will be obtained. The consequences of this commissure are important; for if any second trough follow in series, both sides would be equally excited if either battery acted. In the brain, after the first commissure, any action in the body will act in duplicate.

(102). Throughout the gray matter, or active part of the brain, minute cells are formed, which may be supposed to be the poles of the central batteries. A question arises whether it be necessary for each cell to be insulated. These cells are so diminutive, that no physiologist can ever hope to be accurately informed upon all the changes going on within them, but from the law which I have developed in my work on Electro-Metallurgy, that the voltaic circuit is completed through the easiest road, to the exclusion of all the rest, no such insulation will be required.

SYNDRAMICS.

THE COMBINATION OF SINGLE IMPRESSIONS OF EACH SENSE.

(103). Man, however, is cognisant of associated impressions; and, moreover, the action of the brain clearly indicates that the primitive fibres are associated together in various manners. This combination may conveniently be studied under the term, "Syndramics." Every possible combination of the single impressions of each fibre of the respective organs of sensation must necessarily occupy vast bulk, and must require a multitude of fibres, which circumstance gives us a reason for the vast size of the brain, and its multiplicity of fibres and vesicles. If we represent four simple elementary phreno-aisthenic terminations by A, b, c, d, we might have the following ten combinations of them:—A b, A c, A d, A b c, A b d, A b c d, b c, b d, b c d, c d.

(104). In nature, however, we should have to deal with perhaps 2,000 or 3,000 elements from each organ of sense, which would, of course, in combination, form many thousands; and yet with the extremely minute structure employed in the brain, that organ probably contains room for all the most important, when packed and arranged with the absolute perfection manifested in all the operations of nature.

(105). In treating of Phreno-Aisthenics, I stated that the first pole would be negative, the second positive; consequently in the Syndramic battery the first pole would again be negative. To give identity to these specific combinations, a nerve fibre must alternate with each combination, and this would again in its electrical arrangements be positive.

(106). We may imitate this combination of single impressions very readily by voltaic batteries. The best method is to use, for the last pole of three or more imitative Phreno-Aisthenic batteries, a piece of copper, to which several wires are soldered. These copper wires can be made into all possible combinations, to form the first pole of the Syndramic batteries.

(107). It appears to me not only unnecessary to assume that the sum total of all the fibres of the body should be connected together in every possible manner, but even that such an arrangement would be embarrassing and complicated to the mind. From various considerations, I am inclined to think that this combination is confined to all the fibres of each specific organ of sensation, and that single fibres of each sense do not combine with single fibres of other senses. However, the body, perhaps, as far as the sensor nerves are concerned, is mapped out into regions, between the parts of which alone the combination of simple impressions occur in the Syndramic battery. By such arrangement, it is manifest that the entire number of combinations will be much lessened in number, and the result will accord better with the ordinary properties of the mind.

(108). We have again reason for concluding, that this second pole is connected with the corresponding pole of the opposite side of the head—a commissural arrangement which would be similar to that described in the Phreno-Aisthenic battery.

(109). The exact situation of these commissures in nature is very imperfectly known; though, as this commissure must consist of a very large number of fibres, it would only be fair to assign this proud position to the *corpus callosum*, which all anatomists have agreed to consider as the great commissure of the brain. According to the extent to which these combinations are carried, so must be the required bulk of the commissural apparatus. Perhaps, with our present knowledge, it would not be too much to assign to the cerebellum the office of not only receiving, but combining the impressions of common sensation or ordinary feeling.

(110). To the convolutions of the cerebrum, in like manner, may be assigned a similar office with regard to the nerves of the special senses, except those of the nose, which we may suppose to be combined in the olfactory ganglion, which is diminutive in man, but of enormous bulk in many animals. The various parts of the Syndramic battery, from its vast size, must necessarily occupy the largest part of the brain.

AISTHENIC NOEMICS.

ULTIMATE ASSOCIATION OF IMPRESSIONS OF EACH SENSE.

(111). The human species has cognisance not only of single sentient impressions, and of combined sentient impressions, but we also derive a single idea from the sum total of all the impressions of each sense. As this property appears to belong to man alone, and is consequently a proof of mental power, I have termed this part of the subject Aisthenic Noemics. To

obtain a single impression from a multitude of separate actions, it is only necessary, in voltaic arrangements, to connect all the combined arrangements, so that they may act in a single battery, which single battery will exhibit action, whether one or all of the former batteries were excited. In this way the idea of sight will be given when any of the optic nerves are acted on; of hearing, when any of the auditory nerves; of smelling, when any of the olfactory nerves evince action; and in like manner for the other sentient nerves.

(112). As the second pole of the last battery was positive, the first of this will be negative. The pole opposed to this will again be positive; and here, again, we are led to expect another commissure, as before, with similar actions, on the other side of the body, otherwise we shall have two ideas of sight, hearing, etc. This battery cannot, from its nature, be very great in extent, and is probably situated deep down in the central parts of the brain.

SYNDRAMIC NOEMICS,

OR, COMBINATION OF ASSOCIATED IMPRESSIONS OF DIFFERENT SENSES.

(113). There certainly appears ample grounds for supposing, that the simple impressions derived from the sum total of the nerves of each sense are combined together in a manner precisely similar to that described in Syndramics. I need not in this place again refer to the structure necessary for such an arrangement, but shall content myself with observing, that the effect of such a contrivance in the human body will be to give us an idea of those properties of bodies which we derive from two or more organs of sensation at one time. When, for instance, we see a body, we associate all its properties, as far as they can in any way affect our senses.

This battery would occupy but small space, and is probably placed near the meso-cephale.

PNEUMA-NOEMICS.

TOTALITY OF ALL IMPRESSIONS.

(114). In man, it is imperatively necessary to assume a mechanism which shall collect the ultimate combinations of the respective senses into one whole. This mechanism I shall describe under the term of Pneuma-Noemics, because it appears to be that structure which gives to man the idea of infinity.

(115). Such a structure would be similar in every respect to the Aisthenic-Noemic battery, and therefore need not again be described in this place. The first pole, following the laws of voltaic action, would again be negative. Its opposed pole is in the highest degree important, inasmuch as, at that point, the motor or dynamic nerves spring.

(116). The position of this battery is somewhere in the centre of the Pons Varolii; and when I have plunged a needle into that situation on one or two occasions, I believe that I have observed deflection in the galvanometer. The animal has been, however, invariably killed; and therefore I have not been able to repeat this experiment so often as I could otherwise desire, nor could I judge of the result in so satisfactory a manner, as to pronounce positively upon it.

This completes the structure of the brain, as inferred from voltaic laws; and it is now manifest, that every structure here assumed may be imitated and repeated by voltaic combinations.

DESIRE, A VOLTAIC PHENOMENON.

(117). The faculty of desiring resolves itself into a tendency to act, and is manifested when the central batteries are in a condition of excitement. Desire is to mental operations similar in all respects to tension in electric arrangements. When the desire is gratified it ceases for a time. This phenomenon is similar to an exhausted battery, in which arrangements exist for replenishing the exciting fluid; as in this case, after a time, the battery would again become active and exhibit tension, which I have, in my sources of physics, described as a desire for action ungratified.

LAWS REGULATING THE ACTION OF THE CENTRAL BATTERIES.

(118). It is manifest, by this arrangement, that any circumstance determining the action of the fibres of the aisthenic battery would, or might influence the whole upon certain laws.

1. Each sensor or aisthenic nerve, is opposed to every motor or dynamic nerve, and may thus excite it to action.
2. This circuit would be completed through the nearest motor nerve of the body, because that would be the readiest course, unless there were obstacles offered in some part of that circuit, or adjuvants added to other parts.
3. If any obstacles were offered in any part of the course, the circuit would be completed by some other motor nerve, according to the facility with which the current could pass.

(119). When an aisthenic nerve is excited, it gives a unit of action in the phreno-aisthenic battery; it will influence all

the combinations into which the unit enters in the syndramic battery; it will influence the aisthenic-noemic battery; after which the impression would act upon the combinations of the syndramic-noemic battery, into which that specific sense enters; and lastly, it would be manifest in the pneuma-noemic battery. Thus, the impressions in the phreno-aisthenic battery give us the number. In the syndramic battery we arrive at the form; in the aisthenic-noemic battery we are made acquainted with the organ of sense by which we learned the impression. If more than one sense was excited, it would be learned in the symdramic-noemic battery; and lastly, the pneuma-noemic battery would be acted upon.

(120). In my last illustration, I shewed how an aisthenic impression passed through the brain. I have now briefly to state how a pnemonic impression would act upon the same organ. I think that we may assume that memory probably resides in the largest battery of the brain, or the syndramic battery. If an impression appears in that situation, it will influence the parts of the phreno-aisthenic battery of which it is composed, and probably the aisthenic-noemic, the symdramic-noemic, and the pneuma-noemic batteries will be acted upon.

(121). If a very strong action were made upon the pneuma-noemic battery, it would influence every nerve of the body; and if it were so great as to exhaust them, life would become extinct. It is thus, doubtless, that strong moral emotions instantly destroy vitality.

(122). In the brain, we thus have a mechanism to learn units of sensation, combination of units of sensation; specific sensation, the combination of specific sensation, and totality of all sensation. All these effects have relation to extent; and the infinity or totality of extent may be regarded as the only idea we form of space.

(123). But two or more series of impressions are continually

occurring in man; and whilst one combination remains constant, another changes; and from this relation of the changing to the persistant, the idea of time is deduced. The various effects of time, with regard to impressions of like senses, are manifested in the syndramic battery; those of different senses in the noemic battery, of different combinations of senses in the syndramic-noemic battery; and lastly, in the pneuma-noemic battery we have the idea of absolute concurrence, or "All Time."

(124). When an impression acts upon the phreno-aisthenic battery, it may be of various amounts, which determine its different degrees of action. An impression, up to a certain point, appears to give rise to action by the nearest course; and wherever action takes place, it is found to give us the idea of pleasure, which, in the lower battery, constitutes specific pleasure; when conjoined with the pneuma-noemic battery, absolute pleasure.

(125). On the contrary, however, if beyond a certain amount, exhaustion occurs; the voltaic circuit cannot be maintained in its proper course, and pain arises, which, in the lower batteries, appears as specific pain; and conjoined with the higher, as absolute pain. The transition from pleasure to pain is perfectly sudden. An impression is made upon any part of the body with a pleasurable result up to a certain pitch; but beyond that, pain immediately ensues.

(126). I might, in the present place, dilate largely upon the mechanism by which pleasure and pain may be regulated; but it will be sufficient to give a single illustration of the most simple method, in which, in the voltaic circuit, a strong impression might stop action. If a very minute piece of metal be placed in a glass of fluid, as a positive pole, and a large current be passed through it, the metal would instantly be dissolved, and the circuit could not be completed by that road. What is true of solid poles, is true of liquid poles, or intervening fluid; and where repair is constantly necessary, as we know it is in the brain, a strong impression would more than

equal the ordinary supply, and thus, action, through that combination, would be stopped. The effect upon the brain by a painful impression, appears to amount to more than mere exhaustion, as the part seems damaged permanently, and the action through that road does not again readily take place.

CHAPTER FOURTH.

ELECTRO-PSYCHOLOGY.

PROPERTIES OF THE MIND, DEDUCED FROM THE VOLTAIC STRUCTURE OF THE BRAIN.

127. Units of Sensation. — 128. Combinations of Senses; Syndramic Battery. — — 129. Ideas obtained from the Aisthenie-Noemie Battery. — 130. Impressions from the Syndramic-Noemie Battery. — 131. From the Pneuma-Noemie Battery. — 132. Thought. — 133. Memory and Faney. — 134. Souree of our Ideas of Infinity, Space, Good, Evil, etc., etc. — 135. Results of Organisation. — 136. Free-Agency, and its Modifications. — 137, 138. Crime and Punishment. — 139. Regulation of Actions. — 140. Moral Law. — 141. Conseience. — 142. Religion. — 144. Religion and Seienee.

(127). THE knowledge of external objects, and of the changes taking place within our own bodies, is limited by the units of sensation; for anything which cannot effect an unit of sensation, is inappreciable. Quantity of matter is in like manner known by the number of units of sensation excited. The phreno-aisthenic battery gives a limit to our knowledge. The phreno-aisthenic battery would also shew, like the keys of a piano-forte, whether two or more nerves were acted upon at the same moment. It therefore makes concurrence.

(128). We have the power of recognising combinations of each sense and region separately, by the syndramic battery; we also obtain concurrence of compound impressions of different senses, or of different regions of the body. By the concurrence, or discurrence of impressions of like senses, or by the concurrence or

discurrence of combined impressions, we obtain the notions of the specific time of each event. In the same way that we obtain our notions of specific time, so do we obtain the idea of cause and effect; though, unquestionably, it is far more difficult to learn absolutely the cause, as the time of an event. Specific action and prevented action, which produce pleasure and pain, must also be sought in this battery. In the syndramic battery, Memory also probably resides. In consequence of the probable active nature of memory, it may be inferred that here, when an event is impressed, it rises hereafter to excite future action.

(129). By the aisthenic-noemic battery, the idea of vision is obtained, in consequence of its giving us the cognisance of the totality of the impressions of the eye; the idea of hearing from those of the ear; taste, from those of the palate; odour, from those of the nose; feeling, from those of the skin; and personality, from those of bodily feeling.

(130). Man can obtain ideas of two or more senses at one time by the syndramic-noemic battery; as, for instance, when we regard a solid body, the idea of solidity is derived not only from the eye, but from touch. This battery also enables us to ascertain the concurrence or discurrence of impressions received by two or more of the organs of sense at one time.

(131). Man derives his most exalted ideas from the pneuma-noemic battery; for all impressions here act as unity, and give us the idea of space. All concur, giving us the idea of all time: in fact, this battery gives to man his idea of infinity. If we descend into the aisthenic-noemic battery, the idea of infinity loses its characteristics, and the impression is limited to the totality of the specific senses. If we descend from the totality of the specific senses into the combination or syndramic battery, the impression is limited to some combination of a particular sense or region of the body; and if from this we descend to the phreno-aisthenic battery, we obtain the exact number of units which have affected us.

(132). The mind, however, derives certain powers from combinations of two or three of these batteries conjointly. We obtain the ideas of a thought and of a reality in this manner. An idea is a thought when the bodily action does not concur with the combination which appears to the mind. An idea is a reality if these two combinations do concur. There are times, when indulging in the spontaneous thoughts of the mind, that a question arises to ourselves, whether everything around us is not a dream—a fanciful creation of the mind; and in such a state we are led to doubt whether it be possible to prove our very existence; but the moment we ascertain whether actions of thought concur with actions in the body, the difficulty ceases, and we are enabled to distinguish immediately between a reality and a fanciful creation of the brain. This power is termed Consciousness.

(133). The recurrence of by-gone impressions, gives to us the power of fancy, and therefore we find at once that fiction and fancy can only unite impressions which have occurred at some former time, with some other series of occurrences at other times. Observation, therefore, is the basis of fancy; and a novelist is fruitful in proportion as he notices surrounding objects. He cannot create; he can only put together parts or impressions which he has derived from without. Man, however, having the power of analysing a compound impression into the parts of which it is made up, may again combine its component parts in every other possible manner.

(134). Other combinations doubtless give us other ideas; thus personality and infinity give us the idea of the soul; pleasure and infinity, of good; pain and infinity, of bad; cause and infinity, of God; time and infinity, of eternity; infinity, pleasure, and time, of heaven; infinity, pain, and time, of hell. Personality and all the units of sensation give us the idea of the body; personality, infinity, and time, of immortality. Personality and other totalities of senses, give us the idea of the mind; thought and infinity, of spirit. Lastly, action, infinity,

and pleasure conjoined, give us the idea of virtue; action, infinity, and pain, of vice.

(135). Thus, we perceive that we know from the very organisation of our bodies, that we are immortal; that God exists; that there is virtue and vice, — a heaven and a hell. Man, in every age, in every climate, is compelled, by his very organisation, to believe these first principles. It is not within our power to define these ideas; and if we attempt to descend into particulars upon these mental conceptions, very different specific ideas are attached to the same point. That which is infinite, must not be limited; time must not be confounded with eternity, matter with space, the body with the soul, or material actions with God.

(136). Electro-noemics indicate that man, at the beginning, is perfectly free to act in any manner from external impressions; but after he has once received impressions, these also regulate his future proceedings. He is then necessitated to act well, if he has received good impressions, — badly, if he has received evil impressions. In fact, electro-noemics indicate the fundamental principle of education, for they teach that if you "train up a child in the way he should go, when he is old he will not depart from it."

(137). Electro-noemies should be the basis of jurisprudence. It shews that crime and pain should be associated together at the same time, because a stronger result would attend punishment inflicted the moment the crime was about to commence. Such a course is suitable for the lowest intellects, or persons of the lowest mental capacity. When, however, good principles could be effectively instilled, they would control every action, and prove far more useful.

(138). Electro-noemics also shew, that to produce a strong effect in future actions, a strong impression must be left on the brain. From this cause, punishment should be inflicted upon a man in a healthy, vigorous condition, and neither ill-fed nor debased in energy; otherwise the impression would be transient

or evanescent, and would not deter the party from the commission of future crime. Electro-noemics also indicate that slight and proportionate punishment invariably following crime, would have more effect than severer punishment, with less chance of its infliction.

(139). Moral Philosophy receives many elucidations from Electro-Noemics, as it indicates that there are two modes by which our actions are regulated, the one according to the immediate and bygone specific impressions, the other by general laws overruling every specific action.

(140). The moral law is infinite, and being manifested in the pneuma-noemic battery, rules every specific instance; and hence the desire for virtue would prevent any vicious act. In the lower battery, action will be determined entirely from the pleasure or pain of the immediate impressions; but these actions are controlled by the ideas of infinite pleasure in the higher battery. Hence, from having the idea that virtue leads to infinite happiness strongly impressed on the mind, a vicious action will be controlled even at the greatest immediate pain. On this account martyrs have suffered the most excruciating agony, rather than do that which they believed to be wrong.

(141). When the moral law is but feebly imprinted on the brain, the immediate impression is not controlled, and the man acts according to the pleasure and pain of the particular impression. If the actions deduced from the moral law and those from direct impressions do not coincide, we are conscious that the action has been wrong. This power to distinguish whether the specific action concurs with the moral law we call Conscience.

(142). Religion is the basis of moral laws; and all religions, true or false, are assumed to come direct from God. Religions, whether true or false, have the same effect in controlling the actions from the influence of the higher batteries. The Indian suttee destroys her body under the influence of a

debased religion, in the same manner as the Christian sacrifices his frame, and endures agonising tortures. From these considerations, man is taught the importance of religion; and, *a fortiori*, the necessity that this religion should be a pure, a holy, and an undefiled religion.

(144). The teachers of religion, and the teachers of science, affect the mind through the two opposite extremes of the Electro-Noemic batteries. The former influence men from general principles to control each specific act. The latter trace up specific impressions to general laws. As the mind acts in a circuit, the two courses, although opposite, cannot be contradictory. When, therefore, the teachers of science and the teachers of religion differ, one or both must be in error, as truth, on both sides, must lead to an absolute concurrence in its effects. For ever, then, let these two great teachers of man act in concert, and let them be assured that at last both will arrive, although by opposite methods, at the selfsame absolute truth, which it is the delight of man to attain.

CHAPTER FIFTH.

ELECTRO-BIO-DYNAMICS.

OR, THE FORCES PRODUCED IN THE LIVING BODY.

145. Bio-Voltaic Circuit. — 146. Dynamic Nerves. — 147. Their Distributionl — Muscular Structure. — 148, 149. Muscular Motion. — 150, 151. Voltaic Imitation of Muscle. — 152. Power of Muscle. — 153. Compound Battery, probable existence of in Muscle. — 154. Conjecture. — 155. Circuit during Muscular Action. — 156. Continuous and Intermittent Currents. — 157, 158. Artificial Muscular Machine. — 159. Remark. — 160. Electrical Fishes. — 161. Generation of Electricity in. — 162, 163, 164, 165. Voltaically imitated. — Remarks. — 166. Adhesion of Hydrogen. — 167. Alternation of Electrical Condition of Cells. — 168. Bio-Photo-Dynamics. — Luminous Animals. — 169. Bio-Thermo-Dynamics. — Generation of Animal Heat. — 170. Morbid Increase of Temperature. — 171. Its Effects. — 172. Voltaic Analogy. — 173. Further instance of increased Heat.

(145). THE completion of the Bio-Voltaic circuit is through ertain Dynamic nerves, which, passing to the flesh, produces lotion — to the electric batteries of certain fishes, produces lectricity — to the light-generating apparatus of animals, oduces Light. Besides these forces, more or less heat is pro- uced in most creatures.

(146). All the Dynamic nerves probably arise from the last le of the Pneuma-Noemic battery, and, consequently, each rve is opposed to every sensor nerve of the body. They are stributed to the various organs described as above. In ery organ supplied by these nerves, the necessary amount of

blood abundantly exists; but in each tissue, the manner in which the capillaries are arranged differs, so that the practised anatomist can always instantly distinguish the tissue by an examination of the method in which these vessels are arranged.

BIO-SARCO-DYNAMICS.

(147). Nerves are distributed to all muscles, and the largest supply, according to my own observation, is awarded to the muscles of the eye. The muscular nerves terminate in loops running transversely to the general course of the muscular fibrils. The ultimate part of the flesh appears to be a simple sheath, containing a peculiar matter, which is the true sarcous tissue, or flesh. When the muscle is contracted, the internal matter may be broken into fibrillæ, which are apparently again composed of a series of globules or discs, which the anatomist considers, by the process of contraction, to become flatter, wider, and more approximated together. According, however, to my own observations upon this point, I do not believe that this structure exists in a thoroughly relaxed fibre, which has none of these markings. Perhaps it would be a nearer approximation to truth, to state that the ultimate fibrils contain a homogeneous substance, but that, during contraction, this globular or beaded appearance, is produced.

(148). The essence of muscular motion consists in a change in the arrangement or composition of the matter contained within the ultimate fibrils, so that they become wider and shorter, and by this shortening produce the effects of motion.

(149). Each muscular fibril is completely enveloped by blood-vessels, which run parallel to the fibrils. The supply of bright arterial blood is absolutely necessary for the manifestation of muscular motion, and, consequently, the relation of the capillaries should be fully borne in mind. A good mode of injecting the capillaries is by the exquisite carmine injection

before described, when treating of the mode of injecting the textures of the brain.

According to this view of the case, muscular contraction ensues from the material existing in the ultimate fibre being increased in bulk by changes taking place in consequence of the voltaic circuit.

(150). An artificial muscle may readily be constructed, to act upon a similar principle. To effect this object, the sheath of the ultimate fibre should be imitated by a bladder, or perhaps more strictly by a piece of the gut of any animal. Into the interior of this, a strip of platinised silver and a small quantity of sulphuric acid should be introduced. The gut or bladder should be tied round at both extremities by a piece of strong cord, which would close the apertures and serve for artificial tendons. The whole must then be immersed in dilute sulphuric acid, containing a positive pole of zinc. When the zinc and silver are connected, gas is evolved within the artificial muscular fibre, when it widens and shortens. This contraction acts upon the artificial tendons, to produce any required motive power.

(151). The contrivance just described represents only a single fibril; but in nature, a multitude of fibrils are associated together to form a single muscle. This mechanism can be readily imitated by using a number of pieces of gut associated together like the fibrils of muscle. In nature, of course, the matter distending the muscle must be immediately removed by the vessels,—an effect which in the artificial contrivance might be imitated either by mechanical expedients, allowing the escape of the gas, or by chemical substances causing its absorption.

(152). By both the artificial and natural arrangements, we obtain enormous power moving over a small space. For this reason, tendons are always attached, in the animal economy, to the small end of the lever, and so far play at a mechanical disadvantage: inasmuch, however, as the power is enormous, this disadvantage is of no practical inconvenience.

(153). Considering the vast power of muscular fibre produced from the small amount of voltaic force necessary to cause its action, it has occurred to me that in certain cases, muscle may be a compound battery cell such as we take advantage of in electro-metallurgy, for obtaining many equivalents of results from one equivalent of force. We have alternately blood-vessels and ultimate sarcous fibre, every alternation of which might form one voltaic cell. With this view, as the amount of action would be equal in all the cells, it follows that a great many equivalents of action would arise from one equivalent of voltaic power. We may imitate such an arrangement by using a series of iron plates interposed between the terminal poles of a battery, when we shall obtain as many equivalents of power, as we use iron plates.

(154). Muscular substance is naturally acid, but being the negative pole of the peripheral battery, a certain amount of alkali would be set free during action. Now a question arises "Whether the alkali coming in contact with the sarcous material, may not contribute to the effect?" and this view is supported by the fact, that muscular fibre, placed in a solution of potash, swells and contracts. Hydrogen would also be evolved at the same situation, and therefore the same question is open with regard to that element. Moreover, a substance of very high equivalent might be transferred, and thus produce the contraction. Upon the whole, however, the subject appears to me to demand further study; but perhaps, from all the facts of the case, we are at liberty to assume that the fleshy matter breaks up into totally new compounds, which are subsequently carried away by the blood-vessels by exosmosis.

(155). Perhaps I need hardly again record that one of the easiest experiments of electro-biology, is to determine the presence of a strong voltaic current when the muscle contracts; it is only necessary to insert one needle in the cutaneous tissues, the other in the muscular, when deflection of the galvanometer marks the result, and indicates that muscle is the negative pole of the peripheral battery.

(156). It is a current opinion amongst physiologists, that muscular contraction ensues from an intermittent current, — a point to which I have given my most anxious attention. In experimenting upon this point, all the muscles of the limb of one kind should be left, the others cut across. In this way, I believe that I have ascertained that contraction is maintained by a continuous voltaic current. The subject is surrounded by more difficulties than at first sight appear; for either the commencement or the disruption of the current gives a shock to the nervous system, which always gives an extra jerk. Besides this effect, we are not sure that the current is passing through the muscle; it may pass outside it, and only go through it at the moment of contact, or the instant before disruption, when the easiest road would be altered, and it would therefore take other courses. From a number of experiments performed upon frogs, I am of opinion that the continued current produces continuous muscular action.

(157). After having apparently discovered the true structure of muscle, it occurred to me to consider, how far an artificial muscular engine might advantageously supply the place of the steam engine. For the purposes of exciting our voltaic battery, we must apply zinc, and in my "*Sources of Physics*," I have demonstrated that the cost of zinc to that of coals, as a motive power, would be as a thousand to one. The power obtainable by zinc, through the medium of decomposition, is unlimited,— or, at least, has never been constrained; which fact might possibly enable us to use an artificial muscular machine in certain cases conveniently.

(158). The only difficulty in practice which suggests itself to my mind, is that of applying this nervous power over a short space; for it is quite clear, that the gut of animals would burst with very moderate pressure. In nature, this difficulty is overcome by using tubes of extremely minute diameter, and which, consequently, can bear the pressure without inconvenience, although occasionally even *they* are ruptured. Man cannot,

however, employ such minute structures; his mechanism is neither destined to work with contrivances very minute, as we see in the animal kingdom, nor with matter of so gigantic a size as is revealed to us in astronomical science. The only mode of overcoming this difficulty, is to use structures enormously stronger, so as to be able to take advantage of the unlimited power at our disposal. We might modify the exact application of the principle to suit our powers, and perhaps it may be convenient to obtain the increase of bulk, by solely using the zinc to evolve the hydrogen.

(159). In using the term "*enormous power,*" or any similar expression in this chapter, I simply mean a power capable of moving a heavy weight over a small space, and therefore no economy results therefrom, as the same quantity of primary change of matter ought to give rise to the same force.

BIO-ELECTRO-DYNAMICS.

(160). Many fish have the power, when they please, of giving off large quantities of electricity. Whenever this property is possessed, the creature has a peculiar organisation called the electrical battery. The battery is composed of a vast number of cells, to which a large number of nerves are distributed, which are arranged in their terminal branches so as to run at right angles to the cells. Besides the nerves, blood is distributed to each cell, which does not appear, however, to be very vascular.

(161). From the natural history of these creatures, it is quite certain, that the production of electricity is perfectly voluntary; that is, it is generated only when the creatures perceive the necessity for employing it. The generation of electricity by these creatures, is always attended with great exhaustion; hence it is shewn, that a considerable change of matter occurs during its production.

(162). An arrangement similar to that of the battery of the

electric fish, may be made in various ways. The arrangement which accords most nearly with nature, I shall term the artificial electrical fish. This artificial electrical fish is made by taking an ordinary solution of ferrocyanate of potash contained in a glass vessel. Into this glass vessel, a porous cell with a similar solution is introduced. Now, if a series of these cells be taken, and connected together by platinum wires, so arranged that the inside of the porous cell of one vessel be connected with the interior of the second by a platinum wire, no action will be indicated by the galvanometer. If, however, a current of voltaic electricity be now passed through each cell from the porous tube to the exterior, one compartment, or the hydrogen side, will become alkaline, and the salt will retain its chemical character; the other cell will become acid, and be converted into the red prussiate.

(163). In consequence of this result, the yellow prussiate is *positive* to the red prussiate, and thus a circuit is produced which I should think nearly as powerful as that observed in the bio-electric battery, when we consider the extraordinary number of cells, and their extreme narrowness.

(164). A current might be determined by acting upon a neutral fluid placed on each side a porous diaphragm, and connected together with iron or copper wires. Upon passing a voltaic circuit through this arrangement, one side will become acid, the other alkaline, and thus the electricity will be set loose whenever our artificial nerves act upon the fluid.

(165). In our artificial arrangements, the voltaic fluid acts in altering the liquid in the cells, at right angles to the course of the secondary electric fluid, which is thereby set in motion, which arrangement is perfectly similar to that observed in the real fish.

(166). Many years ago, I discovered that hydrogen might be put into a state of adhesion, and retain that state for days and weeks, and then act voltaically as a positive pole. Any arrangement by which this may be accomplished, alternately

with an oxygenated compound, will give rise to a similar phenomenon.

(167). I do not think it necessary to overburthen this part of my subject by analogous instances; but I may state generally, that any arrangement by which cells may be rendered alternately negative and positive by one voltaic circuit, may give rise to a secondary voltaic circuit, similar to that evinced by the electric fish.

BIO-PHOTO-DYNAMICS.

(168). Many creatures, as the glow-worm, have the power of becoming luminous at pleasure. Other creatures, as the luminous centipede, occasionally seen round London, give off a strong light; but in this case the phosphorescence depends upon an excretion, which, if touched, will give the same luminous appearance to the fingers. I am inclined to believe that cats and other animals have the power of generating light in their eyes by a strong effort on their part, whenever they are much alarmed, astonished, or desirous of obtaining sight of an object in a dark place. If the back part of the eye has the power of eliminating light, the light will be generated in the focus of the refracting media; and, therefore, parallel rays will emanate from the eye, and thus every ray will be thrown upon the object to be illuminated. No mode has at present occurred to me of forming an artificial glow-worm.

BIO-THERMO-DYNAMICS.

(169). Heat is constantly generated by the actions taking place in the peripheral battery. In fact, it appears that the body is warmed by changes taking place all over the body, and this changed matter is simply eliminated by the lungs

and other organs. The peripheral battery, during health, is kept in due subjection by the central; and if the two are severed in any region of the body, the actions at that part appear to run wild and uncontrolled.

(170). Sir Everard Home shewed long since, that if the nerves of a stag's antler were divided, the heat rose. When the spinal marrow is divided, the heat of those parts, from which the nervous supply is cut off, almost invariably rises to several degrees above the temperature of the inner part of the mouth. One of my former pupils, at the Aldersgate Street School of Medicine, unfortunately fractured his spine, and after a few days, the temperature at the groin amounted to as much as 100 deg. Fahrenheit, while in the mouth, or in the axilla, it only reached 96 degrees.

(171). When this additional heat is produced, the muscles rapidly waste away; and in the urine vast quantities of animal matter may be detected, shewing that great change of matter has occurred to produce this phenomenon.

(172). This phenomenon of rapid and extensive change of matter, accompanied with increased heat, observed in the peripheral battery, appears to me to be precisely similar to that observed in an ordinary voltaic battery, where the two plates are connected without any resisting medium between. In animal life, this increased temperature and waste does not commence for a few days after the division of the nerves, and it does not appear quite certain how this local action ensues.

(173). Some observers have recorded, that the heat in a limb has increased, when a main arterial trunk has been tied; a phenomenon, however, which I myself have never witnessed. When, however, we consider the importance of the supply of arterial blood for the proper action of the peripheral batteries, it will not appear singular that the interference with that supply should produce great effect.

CHAPTER SIXTH.

BIO-STATICS.

174. State of Equilibrium.—175. Sleep: Restoration of Powers: Sleep from Cold: Bodily Fatigue.—176. Waking.—177. Excitability.—178. Inactivity.—179. Proper Balance of Bodily and Mental Powers.—180. Importance of Equal Exercise of all Bodily and Mental Functions.—181. Analytic and Synthetic Modes of Instruction.—182. Undue Employment of Portions of Electric-Biological Circuit.—183. Concluding Remarks.

(174). THE sum-total of the entire apparatus of animal life is balanced, or in equilibrium, and remains quiescent till some impression acts upon the aisthenic pole from without,—upon the somaisthenic pole from within; or until some idea rises in the central battery.

(175). After the electro-biological circuit has been in action, a greater or less amount of exhaustion occurs, and a certain time is required for the complete restoration of the functions; and sleep must be regarded as a state wherein excitability is lessened, and restoration takes place. Sleep may almost invariably be produced by a sufficient amount of cold: when the amount is extreme, it causes a sleep so profound, that the subject of it passes into that sleep from which no man awakes. In this way, Napoleon's army perished in Russia; in this way, the traveller dies upon the Alpine passes. In practice, the application of cold will produce this refreshing state when all other medicaments fail or are inapplicable; and many a time I have assuaged a sufferer's pain, by applying a little cold water to the top of

the brain; and have thus obtained for him rest, when every other means have failed. Bodily exhaustion is another great cause of sleep; and I have frequently known farmers' boys, who are most cruelly over-worked, to fall asleep on the road, and receive serious accidents from the carts which it has been their duty to attend.

(176). During sleep, the body is refreshed, the whole bio-dynamic circuit becoming capable of more easy excitation; so that at last, by slight causes, the circuit may be set in action, and the party will awake. We have some voluntary power of being able to go to sleep. We perhaps lower the action of the heart, and the temperature of the body, when sleep takes place, and do not again awake until some unusual impression excites the circuit to action, or the excitability becomes so exalted, as to allow weaker impressions to have the same effect.

(177). The exaltation of the capability to receive impressions, seems capable of being increased to an almost unlimited extent. The eye, constantly kept in darkness, will have its excitability so increased, that the party would at last be enabled to see in the most feeble light; and it is not at all uncommon to find females so to exalt their excitability, as to become a burthen to themselves, from the slightest external influence producing a most painful impression.

(178). The Electro-Biological circuit, then, has its excitability augmented by repose; but this repose must be within certain limits, for any part of the circuit totally thrown into disuse, almost entirely loses its excitability, and becomes more or less powerless.

(179). From the above facts, it is evidently important that we should use all functions of the body proportionately, and rest them after exercise sufficiently. In the Electro-Biological circuit we have two great divisions, the peripheral battery and the central battery; or, in other words, the body and the brain. In these two divisions, the fundamental law shines forth conspicuously, for a well-developed body should be as much

sought after as a well-regulated mind. When the body wastes, it should be exercised to restore its functions. When the brain shews inaction, from too great bodily use, the bodily labour should be lessened; while that of the brain should be increased.

(180). What is true of the entire central and peripheral batteries, is true of their respective parts; the legs should be used as much as the arms; the eyes as much as the ears; and in fact, each individual organ should be employed to its normal extent. In the central circuit, all the various batteries should, in a similar manner, be exercised; for instance, the phreno-aisthenic battery should be exercised by the observation of external objects, and the application of general principles to each specific instance. The syndramic battery should be employed in the estimation of the causes and times of occurrences. To avoid being tedious, by again enumerating all the mental processes, I may state that the mind should be thoroughly exercised from specialities to general impressions, which will give to the individual an acuteness in that particular, and enable him to assign to every fact its due weight amongst other scientific truths. To exercise these properties, youths should be taught the facts and deductions of natural history, natural philosophy, chemistry, and all other similar sciences. This mode of education is practised principally by medical men, and entirely neglected by religious instructors.

(181). The opposite course of the mind, by which it descends from generalisations to specialities, has also to be followed. This mode of education is solely followed by theological teachers, and is much neglected by medical men. The difference in the mode of education gives to each of these classes great peculiarities; but the truly great man is doubtless that person who employs the two-fold method of receiving knowledge, and who ascends from specific instances to generalisation, and descends from universal laws to specialities, and applies them to particular cases.

(182). The observations which have been made concerning a large portion of the Electro-Biological circuit, apply also to all its subdivisions, or minor portions. It appears that one portion of the brain may be thrown into a state of rest, whilst another part is active. This probably comprises all that is true of what are termed "Mesmeric Phenomena." Some time since, I received a very curious account from Mr. Eaton of Norwich, detailing the effects produced on the brain * from the practice of five-finger exercises! The effect of this, when continued for hours together, is to exhaust the corresponding and its contiguous parts of the brain, and to cause the party to exhibit peculiar effects therefrom. The trickling of water and other monotonous sounds have the same effect in producing a peculiar drowsiness.

(183). Perfect health throughout the Electro-Biological circuit, can only be secured by a judicious use of all its separate parts, for we find that men, like ploughmen, who are kept entirely to bodily exercise, are much degraded in noemic or mental power. In like manner, we find that a great diminution of physical capability is found in those who confine themselves entirely to mental exercises.

* A mode of practice adopted by piano-forte students for increasing and equalising the power of the fingers; the fourth, or little finger, being usually feeble in proportion to the others, and the third finger being peculiarly intractable, until well broken in.

CHAPTER SEVENTH.

BIO-ELECTROLYSIS;

OR, THE CHANGES TAKING PLACE IN THE HUMAN BODY.

184. Changes taking place in the Batteries; Waste and Repair. — 185. Arterial Blood. — 186. Conditions necessary for Polarity. — 187. Formation of Polarity in the Animal Batteries. — 188. Artificial-Blood Corpuscule. — 189. Further Illustration. — 190. Changes at the Positive Pole. — 191. Hydrogen and Carbon. — 192. Difficulties attending the Use of Hydrocarbons as Positive Poles. — 193. Combination into which the Hydrogen enters. — 194, 195. Uncertainty concerning. — 196, 197. Dependence of Central or Peripheral Battery for its Action. — 198. Phosphorus in Gray Matter. — 199. Origination of Thought. 200. Waste, and Removal of Effete Matter. — 201. In the Voltaic Battery. — 202. In the Animal Economy. — 203. Remark.

(184). In taking a cursory glance at the changes taking place in the Electro-Biological circuit, we must briefly consider the alterations occurring both in the peripheral and central batteries, because it by no means follows that the same changes occur in both. Such considerations also include the important subjects of waste and repair, for we can no more obtain light without the wasting of the candle, or heat without combustion, than we can animal force without the creature taking food, and excreting effete matters.

(185). At both of the poles of either series of batteries, bright arterial blood, which is a highly oxygenated agent, is distributed; and this bright arterial blood may, for our present purpose, be considered as quasi-oxygen, or as having similar

properties. The electrolyte of both batteries is water, which, however, as serum, contains various neutral salts, which thereby render it a better conductor.

(186). It is a law of the voltaic circuit, that no polarity can occur unless there be some difference in the two poles, either in reference to their individual power of combining with oxygen, or from other circumstances, placing them in different relations; such as variation in temperature, in extent of surface, in state of surface, in fluids having a different affinity for that pole. Whenever we have any differences in any of these conditions, then we have a voltaic circuit determined from that pole which is rendered most capable of combining with oxygen.

(187). Whilst, therefore, bright arterial blood is supplied to each pole, no voltaic circuit could be produced, and some external force must disturb the balance, and cause polarity before that effect would ensue. But bright arterial blood appears to be a combination of easy decomposition; it readily yields its oxygen under circumstances favourable to that object, and in this respect is very similar to a mixture containing oxalic acid and chloride of gold, or gallic acid and nitrate of silver; and perhaps even to red prussiate of potash and per-salts of iron. If at one pole the arterial blood yields its oxygen, the balance is instantly destroyed, and the pole where the blood has become venous, must instantly take on a positive polarity, as the excess of oxygen at the opposite pole would determine a negative character in that situation.

(188). The blood, however, consists of two parts—corpuscules and serum; but the arterial quality is supposed to reside in the blood-corpuscule. The corpuscule may be regarded as a bag holding certain contents, which in the arterial state are highly oxygenated. To make an artificial corpuscule, becomes a matter of much interest. Now, if a little per-nitrate of iron be tied up in a membrane, it will serve to illustrate the voltaic properties of a blood corpuscule. For the purpose of examining

its electrical properties, two pieces of iron should be placed in a solution of salt, and no action will be manifested when they are connected with a galvanometer. The same result will be observed, if one of these bags of per-nitrate of iron be placed against each piece of iron. If, however, one of these bags, or artificial corpuscules, be removed, a powerful current is immediately determined from that pole, and the needle is instantly deflected. In trying this experiment, of course, it is of considerable importance, that the pieces of iron be of the same size, in the same state of surface, and that the artificial corpuscules be brought in contact with them to the same extent.

(189). The bag of per-nitrate of iron, very beautifully illustrates the functions of the blood corpuscule, when used in the manner detailed in the last experiment. But the most perfect mode in which the corpuscule itself can be copied, is by employing a mixture of solutions of proto-sulphate of iron and nitrate of silver, the former being in excess. By applying heat or light to such a corpuscule, more rapid decomposition would ensue, than if it were kept in darkness or cold: hence the oxyde of silver would be reduced from the corpuscule so acted upon, and, as a consequence thereof, the current would start from that point. If an excess of nitrate of silver were employed, the reverse conditions would manifest themselves. The artificial corpuscule might be made by a combination of any two substances,—the one having an *excess* of oxygen, the other having an *affinity for* oxygen.

(190). Having considered the functions of the electrolyte and blood-corpuscule, we have now to study the changes which occur at the *positive* pole. Now, chemistry indicates that large quantities of carbon and water are formed in, and exhaled from, the body; and, moreover, we observe that starch, gum, sugar, fat, taken for food, are thus eliminated, after combining with oxygen. All these substances, theoretically, ought to form the most powerful positive pole known; and although there are difficulties in obtaining their full powers, I have long

since shewn that gum, starch, and oxalic acid, are capable of giving good voltaic circuits with highly oxygenated substances, such as nitrate of silver, nitric acid, and chloride of gold.

(191). In all probability, the active agents of the positive pole, are hydrogen and carbon. The low equivalents of these elements eminently fit them for this purpose, as 1 pound of hydrogen would probably be as effective as 32 pounds of zinc; and 3 pounds of carbon would be equivalent to the same amount of metal, inasmuch as this latter element combines with two atoms of oxygen.

(192). From these facts, I have endeavoured to imitate nature in the use of hydrogen and carbon, but, up to the present time, with very limited success. The hydro-carbons are very insoluble in water, and are imperfect conductors; but perhaps some future experimenters will be more successful; and any person, who could use coke as the positive pole, in an effective manner, would probably have the pleasure of superseding steam engines, the ordinary forms of lights, and in fact, all other sources of power.

(193). So much for the *positive* pole: but, to have an efficient battery, the hydrogen should also enter into combination. Now, the red corpuscule of the blood might be used for that purpose, or the hydrogen might form more complex changes with the sarcous tissue.

(194). To form an opinion upon this matter, we must have recourse to chemical investigation; but, in referring to Liebig upon this point, I must state distinctly, that in the present state of science, I do not think that we are warranted in forming a perfectly definite conclusion upon the subject.

(195). In reference to the changes taking place between the elements of protein, which is largely contained in muscle, starch, oxygen, and water, Liebig states,—"That is to say, that if the elements of protein and starch, oxygen and water being also present, undergo transformation together, and mutually affect each other, we obtain, as the products of this

metamorphosis, urea, cholcic acid, ammonia, and carbonic acid, and besides these, no other product whatever.

The elements of

5 at. Proteine 15 at. Starch 12 at. Water 5 at. Oxygen	} = {	9 at. Cholcic Acid 9 at. Urea 3 at. Ammonia 60 at. Carbonic Acid

In detail:---

5 at. Proteine -	5	$(C_{48}\ N_6\ H_{36}\ O_{14})$	$= C_{240}\ N_{30}\ H_{180}\ O_{70}$
15 at. Starch -	15	$(C_{12}\ H_{10}\ O_{10})$	$= C_{180}\ H_{150}\ O_{150}$
12 at. Water -	12	$(\ HO\ )$	$= H_{12}\ O_{12}$
5 at. Oxygen - - - - - - - - -			$= O_5$
		The sum is -	$= C_{420}\ N_{30}\ H_{342}\ O_{237}$

And—

9 at. Cholcic Acid	9	$(C_{38}\ N\ H_{33}\ O_{11})$	$= C_{342}\ N_9\ H_{297}\ O_{99}$
9 at. Urea - -	9	$(C_2\ N_2\ H_4\ O_2)$	$= C_{18}\ N_{18}\ H_{36}\ O_{18}$
3 at. Ammonia -	3	$(\ N\ H_3\ )$	$= N_3\ H_9$
60 at. Carbonic Acid	60	$(C\ O_2)$	$= C_{60}\ O_{120}$
		The sum is -	$= C_{420}\ N_{30}\ H_{342}\ O_{237}$

The transformation of the compounds of proteine present in the body, is effected by means of the oxygen conveyed by the arterial blood; and if the elements of starch, rendered soluble in the stomach, and thus carried to every part, enter into the newly-formed compounds, we have the chief constituents of the animal secretions and excretions: carbonic acid, the excretion of the lungs; urea and carbonate of ammonia, excreted by the kidneys; and cholcic acid, secreted by the liver.

(196). All those changes which I have already described, appertain only to the peripheral battery; and, from the detail which I have already given, we may infer, that this battery is the main source of power in the electro-biological circuit.

(197). Having an active peripheral battery, the changes taking place in the central battery need only be excited by

virtue of changes occurring in the peripheral battery. In this respect, it will be similar in action to the electro-metallurgic precipitating trough, where no polarity would exist without connection with the battery.

(198). With this analogy to guide us, we find that bright arterial blood is supplied to all parts of the gray matter, or active part of the brain; and in this tissue, a large quantity of phosphorus also resides. Now, phosphorus, of all substances, is remarkable for its ready combination with oxygen, reducing silver, copper, and various other metals, from their solutions. But phosphorus is also remarkable for the facility with which it combines with hydrogen; but the exact part which it plays in the economy is not well understood. Certain it is, however, that phosphates are eliminated by much mental exercise.

(199). In treating of electro-pnemonics, I stated that there were good reasons for supposing that memory was active, and, consequently, we may assume, that after the brain has received impressions, a certain polarity arises therefrom, which gives rise to our thoughts. Upon the whole, it appears to me, that the possible changes occurring in the central batteries are more obscure than those of the peripheral.

(200). Bio-electrolysis now brings us to this proposition,—that no effect in the body can take place in its animal life, without a corresponding change of matter. This change of matter continually causes waste, and demands supply. The changed matter forms the effete material and would clog the system, and interfere with the voltaic agency, were some arrangement not made for removing them.

(201). My much-respected teacher, the late Professor Daniell, had an elegant contrivance to effect the removal of the sulphate of zinc, or effete matter, from the ordinary voltaic battery; and, since his time, patents have even been taken out for an analogous process.

(202). What chemists do imperfectly, nature effects with the

highest perfcetion; for, we perceive that the blood absorbs the carbonic acid as soon as formed, and carries it to the lungs, where it is exhaled. The blood also absorbs urea and carries it to the kidneys, to be there removed, whilst, in like manner, it casts off the choleic acid by the liver. If the first process be stopped but for five minutes, death ensues;—if the second, life is extinguished in three or four days; and we find that it is no less necessary to throw off the effete matters from the electro-biological circuit, than it is to re-charge the ordinary forms of batteries, and cast away the sulphate of zinc.

(203). To charge the electro-biological batteries, we must take suitable food; and to keep them in working order, we must eliminate the changed material. The food we take, is changed into blood; and electro-biology shews, that the blood is the vivifying agent, and explains how the blood of any animal may, in any sense, be said to be "*the life thereof.*"

CHAPTER EIGHTH.

ELECTRO-BIOLOGY OF CELLS;

OR, THE RELATION OF ELECTRICITY TO GROWTH, NUTRITION, AND CIRCULATION.

204. Universality of Cellular Structure — 205. Aggregation of Cells. — Varieties — 206, 207. Arrangement of Cells, Influence of External Forces upon. — 208. Plants, Indication of Polarity in. — 209. Influence of Electricity, Professor Solly's Experiments. — 210. Further Experiments. — On Potato Tuber. — On Germination of Seeds. — 211. Magnetism. — 212. Obscurity of Electrical Influences on Vegetation. — 213, 214. Effect of Intermittent Current on Animal Cells. — 215. Lymph Corpuscule. — 216. Continued Current. — 217. Question as to Effects of Muscular Contraction. — 218. Importance of Electricity as a Therapeutic Agent. — 219. Effect on Vegetable Circulation. — 220. Effect of Increased Current. — 221. Family Resemblance. — Peculiarities of Race. — 222. Propagation of Diseases. — 223. Entozoa and Parasitic Fungi. — 224. Acari observed by Cross and Weekes. — 225. Experiment on Aphides. — 226. Concluding Remark.

(204). The researches of modern physiologists have now shewn, that all organic beings are ultimately resolvable into cells, and that the functions of growth and nutrition are performed through the medium of these organs. These cells are common to all parts of the organic kingdom; and, therefore, to study them in their pure form, we should have recourse to cases where they exist in their simplest conditions.

(205). These cells have manifestly very powerful inherent

forces, otherwise they would not so constantly assume the same form when aggregated together. Although this similarity extends to a certain point, external forces can modify its properties to a slight amount; for instance, the delicious Ribstone Pippin is a modification of the common crab; and the gardener, on the one hand, and the farmer on the other, so acts upon the subjects of his respective business, as to obtain the variety of plant and animal suited to his peculiar want.

(206). Nothing is at present known of the forces determining the arrangement of the cells; for instance, why in different plants such different forms should be assumed, or even in the same plant; why at one time these cells should take on the form of a mere stalk, at another the form of a gorgeous flower. Every gardener, however, knows that the flowering of plants is influenced by external forces; and he constantly talks of "flowering" a plant, as a circumstance as much under his control as digging, raking, or any other human operation.

(207). If we could once modify the inherent forces of the cell, we should give to it new properties. In aggregation, they would then leave their own peculiar form, and assume some other mode of organisation. We find already that the different parts of a single plant differ more from each other than similar parts in different plants. In animals, also, we observe great differences in the same species; for instance, if we compare the racer with the dray-horse, the Italian greyhound with the bull-dog, we shall observe extraordinary modifications of the law of development.

(208). In a plant, then, we have a body made up of individual parts or cells, which contain forces which determine its mode of growth. But inasmuch as the part helps to determine the organisation of the whole, so does the whole modify each particular part. In plants, one part tends towards the light, and makes shoots of yards in length, to be acted upon by that force; another part grows from the light, and seeks darkness.

Here we have a state somewhat resembling polarity; but the mechanism by which it is effected is by no means obvious.

(209). Experimental philosophy has not thrown much light upon the power of electrical force, to determine varieties of cell growth. The influence upon the entire plant is doubtful. Professor Solly tried an extensive series of experiments upon the effect of electricity upon the growth of plants. His paper upon this subject is of great value; but all his investigations have been attended with a negative result.

(210). I have tried various experiments upon this subject on different plants. Amongst the laborious investigations which I undertook upon the cause of the potato-disease, I tried the agency of electricity in all its forms. Slight currents of voltaic electricity, produced by a plate of zinc and copper, had no appreciable effect upon the plant. Plants kept under the influence of electric tension for weeks exhibited no difference, whether positively or negatively electrified. If two platinum poles be inserted into the tuber of a potato, and a strong voltaic current be directed through the part for a short period, the tissue around the poles will become disorganised. The gap, however, heals over, and the rest of the tuber grows as though it had received no injury. I have tried experiments upon the growth of mustard seed, under the influence of voltaic electricity, when I found that every seed which was placed near the positive pole had its vegetating power destroyed, although it is an extraordinary fact, that some fungi grew from the same situation. The result observed in this experiment was apparently electro-chemical, that is, it depended on matter eliminated at that situation, and was not due to the electric force alone.

(211). I have tried the effect of magnetism upon plants, but could not see that any effect was produced. Upon this point, however, I am dissatisfied with the result of my own investigation. I should like to see the subject further examined.

(212). The world some time since was startled by the

announcement that electricity materially enhanced the growth of plants. Electro-culture was to supersede every other form of culture, and manures were to be exchanged for the voltaic force. Further investigations proved these hopes to be groundless; and the influence of electricity upon plant-growth remains yet unknown. In nature, we have, during the thunder cloud, vast quantities of electricity of high tension passing; an effect which, as we cannot imitate, we are unable to employ for the purposes of experiment.

(213). With regard to the cells of animal bodies, one of the most wonderful and extraordinary results which I have observed, is the action of electricity derived from the intermittent current of the various forms of electro-magnetic machines. When a frog's foot is arranged in the field of the microscope, and the intermittent current is directed through the animal, the circulation instantly stops, as though by magic. The current in the veins, indeed, seems slightly to retrograde, though it still continues its course for a short period in the arteries; the whole effect giving the appearance of all the corpuscules having a tendency to be drawn into the capillaries.

(214). In consequence of the corpuscules being drawn into the capillaries, an engorgement of them results. When, however, the current is withdrawn, the blood moves again more rapidly than before, and is instantaneously again stopped, when the current is renewed.

(215). The action of the intermittent current is as decided upon the lymph-corpuscule, as it is upon the common corpuscules; for although, ordinarily, they run their course at a very different rate from the common corpuscules, they are stopped as suddenly by the intermittent currents. The interference with the circulation of the lymph-corpuscule in the capillaries is of more importance than that of the common corpuscule; because, crawling along the side of the vessel, and apparently in contact with it, it is manifestly less acted upon by the *vis a tergo* of the heart's action.

(216). When the continued current is employed, instead of the intermittent, the experiment is perhaps rather more difficult: yet, if the current be passed completely through the body, precisely the same result occurs. I have seen the circulation absolutely stopped from the very feeble current of a dozen pairs of plates. The difficulty in this experiment is, to be sure, that the voltaic force actually passes through the capillary.

(217). In these cases, where the circulation is stopped, it becomes a question, whether the contraction of the muscles has any share in the phenomenon; for it is an undoubted fact, that the result is more evident when muscular substance is included. This question, however, although it has an important bearing upon the theory of the phenomena, does not interfere with the fact itself. It appears to me, that the effect upon the lymph corpuscule almost settles the question of any possibility of mechanical causes.

(218). I need hardly state, that the bearing of these experiments is in the highest degree important; for it shews, that in whatever process of the body blood is necessary, there the electric force must have an influence. As it is manifest, that the circulation of the blood affects, more or less, every operation of the body, I need hardly state, that the experiment demonstrates the importance of electricity as a therapeutic agent.

(219). Having ascertained the important influence of electricity upon the circulation of animals, I was naturally anxious to ascertain the effect of the currents upon the circulation in certain vegetable tissues. To ascertain this fact, I placed a piece of the Valisneria under the microscope, and submitted it to the intermittent current, but I could not perceive any effect, although the self-same current would have stopped the circulation in animals, as suddenly as a stop-watch would have its movements prevented by putting up the stop.

(220). When, however, the continued current of about twelve cells of my battery was employed, and the circuit was completed for a few minutes, the globules circulating in the

plant were stopped as effectually as those of the blood-corpuscules. They appeared to me to leave the sides of the parts round which they revolved, and to become aggregated together in the centre. The value of these experiments, whether the effects are chemical or electrical, it is difficult to estimate, as in the one case we employ a current of intensity; in the other, of quantity. At present, we had better be satisfied with the assertion, that a feeble, continued current of electricity maintained for a few minutes, stops the circulation of the Valisneria.

The action upon the continued and intermittent currents, appeared the same upon other plants as on the Valisneria.

(221). I have before called attention to the inherent power of the cell, which renders it extremely difficult so to be acted upon by external causes, as to exhibit any decided variation in a body aggregated together. This inherent power gives to families their likeness, and causes the father to live again in his children. It retains the peculiarities of races, and gives the specific character to each individual species. Inasmuch, however, as the cell appears to be capable of being influenced by external causes each person possesses some slight individuality. Varieties occasionally arise, such as black men, white men, albinoes, six-fingered men; and in fact, men with every conceivable difference. These varieties, when produced, propagate like varieties, or like varieties in all essential points.

(222). The inherent power of the cell, renders it highly necessary for parties to contract marriage with healthy individuals. Insanity, consumption, idiotcy, and even trifling defects are propagated from parent to offspring. Every Insurance-office in the metropolis, before granting a policy, enquires into the peculiarities of the family, to ascertain the disease likely to supervene. Peculiarities of mind and body are propagated, and therefore the inherent power of the cell should always be considered before matrimonial union.

(223). It becomes now a matter for investigation, how far a totally different organic being may spring from another organic

body made up of cells. In practice, we find that animals are found in internal parts of other animals, where by no possibility they could have been carried, either in the form of an egg, or of a living creature. We find also, that from organic matter, other organic forms are continually arising, without proof of any seed or germ having been placed there. From these considerations we are led to enquire, whether external forces may so act upon the cell as to give rise to a totally different form of organisation. It still remains, however, an unsolved question whether parasitic fungi, as that found in the ringworm of man, parasitic creatures, as the *echinococcus hominis,* the tape-worms, and other bodies are produced by virtue of the cells of the human being taking on new forces, and aggregating in new directions; or whether the germs are carried there in some unknown method.

(224). The only experiments which bear upon this question, are those performed by Cross (fig. 2) and Weekes (fig. 3), who state

Fig. 2.

Fig. 3.

that by subjecting various solutions to the action of the voltaic force, certain acari made their appearance; the acarus found by Weekes differing from that observed by Cross. Now, I tried somewhat similar experiments to see if any creature appeared,

but have never observed anything of the kind, which could at all be traced to voltaic origin. But these experiments deserve frequent repetition by those who have the abundant funds of rich institutions at their disposal.*

(225). During last summer, I subjected the Aphis Vastator to the action of electricity of tension for a long period, and one brood was kept negatively electrified, the other positively; but after some period, when they produced young, I found on one pole the Vastator; at the opposite, the Bean Aphis. The experiment is tedious; and to me, who have no assistant, very laborious. It has not therefore been repeated over and over again to demonstrate its accuracy and universality; and therefore I can only mention it as a faint suspicion, that possibly the character of the kinds was modified by the electricity. I was induced to try the experiment, because the two kinds in nature appeared to be in some degree vicarious of each other; and changes in their relative number occur after electrical disturbances in the atmosphere. If the experiment were confirmed, it would not amount to a great deal, because the Bean Aphis and Vastator do not differ more than a white man and black man; and in either case the individuality is propagated.

(226). There is, amongst those endowed with little minds, an unwise, an unjust, and a false prejudice against those who undertake such investigations. It is assumed that such men are infidels and atheists, and possess every other bad quality, to which hard terms have been assigned. Such parents bring up their children to despise the investigation; and the finger of scorn is pointed at all who dare consider the subject. On this account, this matter of vital importance has not received the labour and talent it merits. It has already been proved by Schwann and Schneider, that a cell is the basis of all organic bodies. And if hereafter it shall be discerned, that from modifi-

* I have just received a letter from Mr. Weekes, stating that he has lately observed two more species of acari produced from other solutions.

cations in the inherent power of the cell, different organic bodies result, what a sublime view would it present to the human mind! And the fact might justly be held by some future Paley, yet unborn, as the most powerful proof deducible from nature of the infinite power and wisdom of God.

CHAPTER NINTH.

ELECTRO-BIOLOGY OF THE SPINAL CHORD AND SYMPATHETIC SYSTEM.

227. Involuntary Actions.—228. Spinal Chord.—229. Great difficulty of arriving at satisfactory conclusions by Experiment.—230. Great Sympathetic.—231. Ganglions in Connection with.—232. Imperfect Functions of, with Relation to Nocmic Batterics.—233. Remark.—234. Voltaic Imitation.—235. Strong Mental Impressions.—236. Action of Parts which are supplied from the Sympathetic System.

(227). In the entire arrangement of the body, there is reason to believe that a certain combination of aisthenic impressions gives rise involuntarily, that is to say, independently of the nocmic battery and without any mental effort, to certain results.

(228). The mechanism by which these phenomena are produced might, with some shew of justice, perhaps, be sought in the gray matter of the spinal chord. This structure is evidently vascular, like the gray matter of the brain; and although difficult to inject, I possess most beautiful preparations which I have made with the carmine injection before described, and in which the minutest ramifications of the capillaries are filled.

(229). In conducting experiments upon such movements in the lower animals, where the brain is removed by decapitation, or but a segment of the spinal chord is left, great difficulties occur in the consideration of all the phenomena observed; for, we must remember that we have the peripheral battery left

entire in all its parts; and though the connections of the wires may be severed, yet it is possible that the circuit may be completed by some other path, and thus interfere with any theories supposing the spinal chord to give origin to the movements. Under such circumstances, it appears to me that every experiment should be carefully weighed in the mind, and studied in reference to ordinary voltaic laws, before we pass an opinion as to whether any involuntary current comes from the organisation of the peripheral battery alone, or whether it is due to specific arrangements in the spinal chord. There is no evidence of any memory existing in any part of the apparatus. This subject deserves much labour from the hands of the electro-biologist.

(230). We now, however, come to speak of a very peculiar nervous mechanism, termed the great sympathetic nerve, which supplies a large amount of the internal organs of the body. Now, in all the parts to which this nerve is distributed, we have but a feeble knowledge of the changes going on. This knowledge is extremely imperfect, or, I may say, that an unit of sensation is only derived from a large extent of body. From these facts, it is apparent that the multitude of nervous fibres distributed to the alimentary canal, to the heart, and other viscera, do not carry separate impressions to the brain.

(231). The anatomy of this nerve corresponds with its physiology, for the fibres are traced to certain ganglia, which possess a structure somewhat similar to the gray matter of the brain. From these ganglia, however, other fibres travelling to the spinal chord exist, indicating the means by which our impressions are carried to that organ.

(232). From the above facts, we are in a position to assert that the ganglia of the sympathetic nerves are rudimentary brains, which might be evolved in structure to such an extent, as to render us cognisant of minute changes taking place in our own bodies, but which, for many hundred filaments, only send a single impression to the noemic batteries in the skull.

As a consequence of this we know that the heart is beating, but we cannot distinguish all the minute parts of each beat, as we can the minute movements of the fingers, or other parts of the body. We may know that we have a pain in our stomach, but we can never refer it to its exact locality with the same exactness of localisation which attaches to impressions received in situations where the units of sensation are more frequently distributed.

(233). It will not be difficult to conceive a being who shall be cognisant of every single change taking place in his body; but whilst, in this respect, we must admit our imperfect organisation, yet we have reason to rejoice at the goodness of Providence in having withheld that knowledge from us. How miserable would be the being who saw mentally every step in the growth of tubercles in the lungs, or other fatal disease; and to what danger should we be exposed, if the assimilation of our food, or the action of our hearts, were regulated by our own volition.

(234). A mechanism, by which a multitude of fibres may transmit a single impression to the brain, may be readily imitated by voltaic electricity, by placing a dozen or more wires in a battery cell as one pole, and by opposing a single wire to the whole. By this arrangement, an impression transmitted down the one wire would affect the twenty, or any one of the twenty, the one opposed wire.

(235). It is manifest, that from a structure like this, a mental impression might produce the most powerful results; and, in practice, we constantly find that the heart's action is interfered with, or even altogether stopped, by a strong mental emotion. In like manner, the entire process of digestion and assimilation may be instantly stopped by sudden joy, grief, or other powerful action of the mind.

(236). The parts supplied by the sympathetic system are principally excited to action, not so much by the direct influence of voltaic power emanating from the brain, as from a

direct stimulus supplied to themselves; and perhaps partake of the action of a closed voltaic circuit excited to action by a supply of arterial fluid. The heart acts when blood, i.e. good arterial blood, is supplied to its fibres; but if hot water or black blood are in contact with the muscular fibres, the action is immediately stopped.

CHAPTER TENTH.

ELECTRO-THERAPEUTICS.

237. Electro-Therapeutics; Preliminary Remarks, — 238, 239, 240. Frictional Electricity; Apparatus for. — 241. State of Tension in the Human Body. — 242. As a Therapeutic Agent. — 243. Aura. — 244. Sparks. — 245. From Cats. — 246. Leyden Jar; Shock, as a remedial Agent. — 247. Leyden Battery. — 248. Electrometers. — 249. Lightning; its discharge through the Human Body. — 250, 251. Various effects of. — 252. Electric Eel and Torpedo. — 253. Hydro-Electric Machine. — 254. Thermo-Electricity. — 255. Voltaic Electricity. — 256. Voltaic Electricity; its quantity; easy Bodily Application. — 257. Galvanic Rings and Bracelets. — 258. Cruikshank's Battery. — 259. Voltaic Pile. — 260. Couronne de Tasse. — 261. Electro-Therapeutic Battery. — 262. Sulphate of Copper; Platinised Silver, and Nitric-Acid Batteries. — 263. Water Battery. — 264. Remark. — 265. Action of Voltaic Electricity on the Body; Theory. — 266. Its application in Tic-douloureux. — 267. Voltaic Blistering; Anecdote. — 268, 269. Action of Muscle. — 270. Disorders dependent on the Circulation. — 271. Remark. — 272. Electro-Magnetic Apparatus; General Remarks; Quantity and Intensity. — 273. Theory of Action. — 274. Primary Coil Machine. — 275. Secondary Coil Machine. — 276. Modification of. — 277. Various ways of Completing and Breaking the Circuit. — 278. Necessity for Uniform Current. — 279. Instrument for obtaining. — 280. Electro-Galvanic Machine. — 281. Remark. — 282. Regulation of Power; various means. — 283. Action on the Body. — 284. Magneto-Electric Apparatus. — 285. Broken and Continuous Current from. — 286. Observation on. — 287. Advantages of. — 288. Adjustment of Power. — 289. Magnetism applied to Animal Bodies. — 290. Analogy. — 291. Result of Experiments. — 292. Statements by Laennec; Remarks on. — 293. Electric Evolution of Heat. — 294. Intense Heat. — 295. Electric Cautery; Remarks on. — 296, 297. Various Cases and Modes of Application. — 298. Observation. 299. The Electric Light; Remarks on. — 300, 301. Voltaic Electricity; its Decomposing Power as a Medical Agent. — 302. Effects produced at Positive Pole. — 303. Suggestion. — 304. Thermo-Electro-Therapeutics; Remark. —

305. Influence of Temperature on Voltaic Action. — 306. On the Human Frame. — 307. On Vegetable, or Cell Life. — 308. On the Human Batteries; on Bodily Pain. — 309. Light; its Effects on the Body. — 310. Absence of Light. — 311. Central Batteries; Moral Effects. — 312. Employment of, by the Practitioner. — 313. Pharmaco-Electro-Therapeutics. — 314. Food; Transfusion of Blood. — 315. Drinking of Water. — 316. Effects of Wind. — 317. Friction of the Surface. — Various Forces influencing the Electro-Biological Circuit.

(237). HAVING found that complicated electrical changes take place in the human frame, we may necessarily expect that electricity should be an important remedial agent. In using electricity we must remember its two-fold character; firstly, its intensity, secondly, its quantity, and use the one or the other according to circumstances. We have, moreover, to consider the various forces which may be produced by electricity, so far as they may be used as therapeutic agents; and lastly, we have briefly to study agents and forces from other sources, which may influence the voltaic current in the human body.

FRICTIONAL ELECTRICITY.

(238). By frictional electricity, we obtain great intensity with but very feeble quantity. It is produced by the friction of any non-conducting substance; as, for instance, by rubbing sealing-wax or a glass-rod with a silk handkerchief. Practically, either a cylindrical machine (fig. 4), or

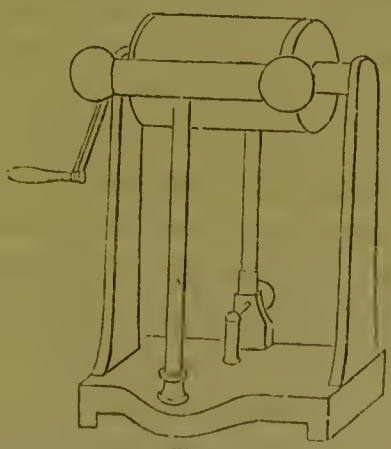


Fig. 4.

a plate machine (fig. 5) are employed. In both cases, the

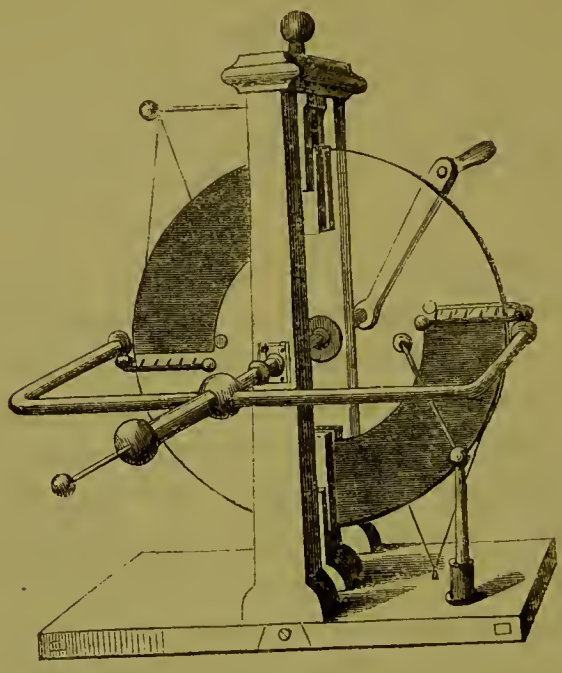


Fig. 5.

electricity is evolved from the surface of the glass rubbing upon the rubber or cushion. The glass becomes positive; the rubber becomes negative. To maintain a constant supply of electricity, either the rubber or the prime conductor must be connected with the earth, which is best effected by a chain passing to the gas-pipes or water-pipes. When we desire positive electricity, the chain must be connected with the rubber; when negative, with the conductor.

(239). In using this machine, it is absolutely necessary that the air should be as free as possible from hygrometric moisture; and that all the parts of the machine should be kept dry and warm. The rubber should be coated with amalgam, and should exert due pressure on the glass.

(240). The largest specimen of an electrical machine, perhaps, is to be found in the Royal Polytechnic Institution, where the instrument is truly of a colossal character, and is worked by a steam-engine. There are also in the Royal Institution some electrical machines of great power.

(241). Frictional Electricity may be employed, first, to throw

the human body into a state of tension, either negative or positive. To effect this, the person should be placed on a stool with glass legs (fig. 6); or, if in a bed, by placing the feet of the

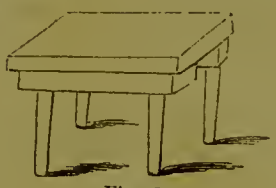


Fig. 6.

bedstead on blocks of glass. Having thus arranged the patient, he may be negatively electrified by connecting his body by a metallic wire to the rubber of the machine; and positively, with the prime conductor. In a room where an electrical machine is in action, every single object is negatively electrified if the rubber be connected with the room; and positively, if the conductor be connected with the room by a chain, or other conducting material. When a party is under very strong electrical tension, the hairs of his head will diverge like the accompanying representation (fig. 7).

Fig. 7.

(242). From my experiments, however, both upon animals and plants, the utility of tension as a therapeutic agent is very slight, or even doubtful. We are almost always under more or less tension, as, normally, the air is positive, and the surface of the earth, with all objects upon it, in a negative state. Perhaps, as a matter of observation, I may assert that the absence of electricity produces uncomfortable feelings in many persons;

and perhaps an excess is also unpleasant. We find that nervous females constantly suffer before a thunder-storm; and hysterical females shew marks of hysteria. In these cases, however, it is difficult to tell whether the effect is owing to the electricity, or to other concomitant states of the atmosphere. When the storm is absolutely raging, fear may be the cause of the result; and I have seen terrible effects produced by the great alarm which a thunder storm excites in the minds of some individuals.

(243). When a human being is in a state of high tension, and any pointed conducting body is brought near to him, the electricity is drawn off very gently from all the surrounding parts, giving rise to the phenomenon, called "The Aura." The Aura would only perhaps act as a mild stimulus to the aisthenic pole of the peripheral battery. It might perhaps be advantageously used to very delicate organs, like the eye or ear.

(244). We may next employ frictional electricity to draw sparks from the body, which amounts, in fact, to the passage of feeble electricity through the part. To effect this object, the body should be arranged in the same way as when we desire to throw it into a state of tension. When a high state of tension is procured, sparks will emanate freely from any part of the body to which any conducting body is approximated. The utility of sparks is considerable, where a stimulus is desired to any part of the body. It may be employed with advantage, when any of the aisthenic batteries act but feebly. Whether there be a deficiency in the power of vision, of feeling, of tasting, and perhaps even of motion, in superficial muscles, it may be usefully employed when the medical practitioner believes a stimulus is desirable. Where a stimulus is considered likely to be injurious, electric sparks should not be used. By the use of electric sparks we may make the skin red, indicating that it has effect upon the capillary vessels

(245). The effect of sparks may be readily tried upon cats, as their own skins constitute an electrical machine, and may be excited by means of a dry silk handkerchief, especially in

dry frosty weather, and after the cat has been warming herself before the fire. By stroking the fur in the wrong direction, a copious supply of sparks will emanate therefrom, and poor pussy will generally shew her discomfiture, by mewing most bitterly if the operation be long continued. Some persons in brushing their hair during easterly winds will give rise to electricity, which will shew itself by the evolution of sparks.

(246). Sparks consist of a very minute quantity of electricity at a high tension. We may increase the quantity by a contrivance called a Leyden jar (figs. 8, 9). By this instrument

Fig. 8.

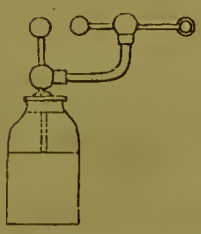


Fig. 9.

the electricity is accumulated, and produces far more powerful results when acting upon the system, as it gives rise to the sensation of a shock. Druitt mentions a case of dislocation of a finger by the shock from a Leyden jar. The shock of the Leyden jar has been thought by some persons likely to be serviceable in supposed death from lightning, and curious cases have been related, wherein after an animal has been stunned by electricity, it has been revived by a shock transmitted in the opposite direction.

(247). When any number of Leyden jars are associated together, the arrangement is called a Leyden battery (fig. 10);

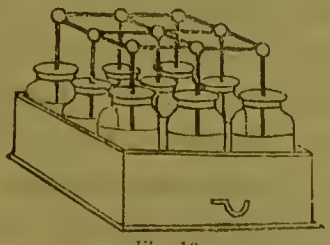


Fig. 10.

and the force may be accumulated to such an extent as to be capable of killing small animals; but neither the Leyden jar nor battery are at present employed for therapeutic purposes.

(248). The power of charges contained in Leyden jars and batteries, may be ascertained and regulated by Lane's discharging electrometer (fig. 9), which estimates the power by measuring the distance in air which the discharge is capable of traversing. Relative strengths of electrical charges may also be learned by Henley's quadrant electrometer (fig. 11).

Fig. 11.

LIGHTNING ELECTRICITY.

(249). Lightning Electricity is a force of electricity eliminated during the formation of the thunder-cloud; and it is distinguished both for its vast quantity and for its enormous intensity. When the discharge occurs through the human body, it may in certain cases instantly destroy life. When it thus acts, it may exhaust at once the electro-biological circuit, and annihilate life. Sometimes all the parts of the entire electro-biological circuit are not destroyed, but portions are alone affected. In some of these cases the symptoms of apoplexy present themselves, such as blindness, deafness, or a greater or less amount of paralysis. If we turn to the published statements of these injuries, we shall at once perceive that every possible injury does at various times occur to the electro-biological circuit from the electric discharge.

(250). In the cases lately described, the effects are due to the impairment of the functions of the batteries from the exhaustion produced by the electric discharge. Lightning may also produce the effects of heat upon the body, and give rise to blisters, burns, and other discolorations. When heat is generated, it may act upon surrounding objects; hence watches and coins have frequently been melted at the same time.

(251). Besides the effect of heat, lightning has the effect of disintegrating or tearing asunder the parts of organic bodies. This is constantly seen when trees are struck by lightning, as the limbs are torn from the trunk, and the bark stripped off. Sometimes, in human beings, the flesh is torn, and extensive lacerations may occur from the effects of lightning.

ANIMAL ELECTRICITY.

(252). The discharge of the electric eel and torpedo, from its quantity and intensity combined, enables these creatures instantly to kill their prey by directing a current through them; and the stoutest lifeguardsman has been known to faint when he has been acted upon by the shock. Of course, we can conceive it possible to employ this power, though from the scarcity of the creature, it has not, and perhaps never will be, used as a therapeutic agent. Animal electricity would be, in its effects, intermediate between frictional and lightning electricity.

HYDRO-ELECTRICITY.

(253). A very powerful electric current can be produced by high-pressure steam, by means of a peculiar apparatus called a hydro-electric machine. In this machine, the friction of the

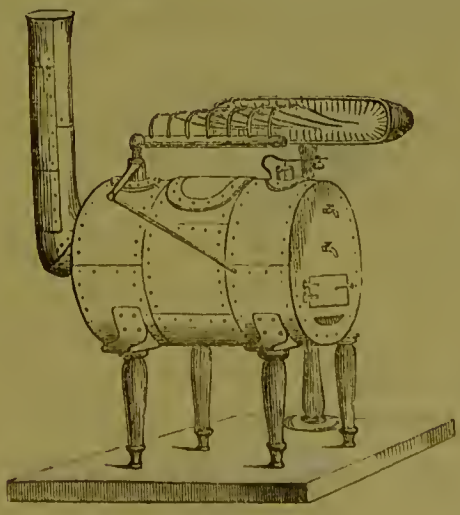


Fig. 12.

steam against wood gives rise to the electric force. The hydro-electric machine gives rise to a larger quantity of electricity at high tension than ordinary frictional machines. An objection to its use would be its cost in the first instance, and the trouble of making it; and I must confess, that working with high-pressure boilers creates an unpleasant idea, which, after all, is not unlike sitting upon a barrel of gunpowder. If it should hereafter be proved, that electricity is beneficial to the growth of plants, this form of apparatus will probably be preferable to all others. For electro-therapeutics, it is only calculated for hospitals, or those who make a business of it; and, at any rate, at present, does not appear to be likely to be employed. If, however, any state of a patient is hereafter shewn to be benefited by electric tension, this instrument might be used to keep a ward of any size, and all the persons in it, under that particular state.

THERMO-ELECTRICITY.

(254). A very feeble current of electricity is set in motion when alternate bars of various metals, but particularly of bismuth and antimony, are soldered together (fig. 13). The electricity thus evolved, possesses but little of the property of quantity, and even less of intensity. It has been employed for determining the

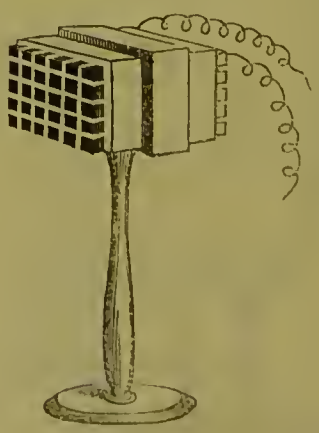


Fig. 13.

temperature of various tissues of the body; although, up to the present time, no use for it has been found in electro-therapeutics.

(255). Voltaic electricity is that form of electricity which is set in motion in a voltaic battery, and is remarkable for the enormous quantity of electricity evolved, with but little power to overcome obstacles. We cannot, however, take advantage of the enormous amount of electricity which is set in motion by large batteries; in fact, if we could only force the electricity, capable of being evolved from a single square inch of negative metal, we should instantly cause the destruction of an animal.

(256). We may cause voltaic electricity to act upon the body in a very simple manner; for instance, by simply inclosing a portion of the body between two dissimilar metals, a current is generated; thus, if a piece of zinc be placed on the under surface of the tongue, and a piece of copper or silver at the upper, a circuit is formed, and we know that voltaic action has occurred, from the organ of taste being stimulated, and a peculiar sensation produced.

(257). Such a mode of excitation will answer for the mucous membranes, which are constantly moist. It would also answer for the skins of frogs, but our skins do not seem to be favourable for the transmission of such impressions, and consequently galvanic rings, galvanic bracelets, and all other similar electro-therapeutic curiosities, may be supposed to be quite inert. Some years ago, there was a vast rage for such contrivances; so much so, that, for a time, it was difficult to supply the demand. Of course, abundance of testimony could be produced, of their efficacy; in fact, as much as for any other quackery; but, from an impartial investigation as to their merits, there appeared to be no sufficient grounds for supposing that they possessed any influence.

(258). In acting upon animals, we have generally to influence bodies with but an imperfect power of conduction; so that we require a high series, or great intensity, although but a small amount of electricity passes at each moment. The form

of battery which has heretofore been chiefly employed by the electro-therapeutist, is a many-celled, or Cruikshank's battery, which consists of alternate layers of copper and zinc, with a layer of fluid between each pair. A battery of this kind, consisting of fifty cells, forms a very effective instrument for the electro-therapeutist (fig. 13).

Fig. 14.

(259). A voltaic pile consisting of from twelve to fifty pairs of zinc and copper plates soldered together, and charged by inserting a piece of lint moistened with salt and water, will also form an effective electro-therapeutic battery.

(260). The Couronne de Tasse, made of zinc and copper wires, or better still, of zinc and silver wires, in a series of about fifty, forms a very valuable electro-therapeutic battery.

(261). The standard battery, which I prefer for electro-therapeutics, is made by using small glass vessels, with a thin partition of porous earthenware, to prevent the contact of the positive and negative metals of the arrangement. For the battery itself, pieces of zinc about the eighth of an inch in thickness, and an inch and a half long, and half an inch wide, are employed; these should be thoroughly amalgamated with mercury, to stop local action; and when prepared, they should fit into a binding screw, to which a narrow slip of platinised silver is soldered; and the whole should be arranged in series like the Couronne de Tasse. This battery is charged with water, to which one eighth of sulphuric-acid has been added, and if the whole is properly arranged, will last in action two, three, or four weeks without any alteration. I have recommended that they should be kept in series of a dozen, so that about four batteries would be required for an effective instrument. This instrument is sold by Messrs. Horne and Thornthwaite, under the term of the "Electro-Therapeutic Battery."

(262). The sulphate of copper batteries, the nitric-acid batteries, or the platinised silver batteries, on a large scale, are hardly applicable for the Electro-Therapeutist, as he requires a high series to drive even a small amount of electricity through the body.

(263). By the water battery of large series, we obtain high tension with but very feeble quantity. It is a form of battery not generally used for medical purposes.

(264). Before describing the effects of voltaic electricity on the body, I may mention that in a subsequent part of this chapter, I shall have to speak of certain secondary results which come from voltaic action, such as the effects of heat, light, and decomposition, which may arise therefrom; but at present I will confine my attention to the results obtainable by voltaic electricity.

(265). When voltaic electricity acts upon the body, the aisthenic pole is excited. In the skin, the ordinary sensation of feeling is produced, which, if long continued, will increase to positive pain; at the eye, we obtain a flash of light; at the tongue, the sensation of taste. The theory of this action is doubtless the excitation of the voltaic batteries in the body, upon the principle of electricity determining polarity, and consequently setting in motion voltaic force, where the elements of a voltaic battery exist.

(266). Great care is required in the use of voltaic electricity, because it may exhaust the nervous power of the parts on which it acts, and thus may effect great mischief. In certain cases, I think it might be employed for the purpose of destroying sensation in cases of extreme pain, such as that of tic-douloureux, painful stumps, etc. In these instances, a decidedly powerful current should be passed through the part, and the amount of electricity may be estimated by the amount of hydrogen visibly evolved from the platinised silver in the voltaic battery; for if a very feeble current passes, but very little gas is evolved; if a stronger one, a greater quantity of hydrogen passes off.

(267). Without care, the skin is apt to be blistered by the voltaic force; and I lately heard an amusing statement of a gentleman who purchased a Cruikshank's battery, with which, having clumsily blistered himself, he desired to return the instrument to the maker, because, as he stated, the instrument generated electricity of a peculiarly acrid nature. When we desire to prevent blistering, the poles coming in contact with the body should be kept continually in motion.

(268). The sarco-dynamic pole of the peripheral battery, or muscular substance, is excited by the voltaic force. I have already mentioned, when treating on Sarco-Dynamics, that although a jump of the limb occurred when the current was either completed or interrupted, yet I found by careful experiments, that muscles are kept in a state of contraction by a continuous current.

(269). If, however, too great a current acts through the muscles, such exhaustion takes place that contraction will not again for some time ensue; and a question arises, whether it may not be turned to good account for the alleviation of tonic spasms, which I shall hereafter have to consider more minutely.

(270). The voltaic force also interferes with the circulation of the blood; hence, all changes in the body depending upon the circulation may be influenced by voltaic electricity.

(271). In applying voltaic force, we may conveniently employ poles covered with lint or sponge dipped in salt and water. The salt renders the water a good conductor; and the water comes into immediate contact with the skin.

COIL AND ELECTRO-MAGNETIC ELECTRICITY.

(272). We have under this head to consider forms of apparatus which are important, inasmuch as they are most frequently employed by the electro-therapeutist, and constitute

the ordinary medical machines. These machines, however, are constructed in many different ways, and on that account require a somewhat particular description. They possess, nevertheless, in all cases, the same property, namely that of obtaining an intermittent current of intensity from a primary current of quantity. According to the primary laws of physics, we can only derive force from some prior change of matter, which change ultimately resolves itself into some new attraction. If we have a certain amount of action in a single voltaic battery, it gives us the effect of quantity; when the action takes place in a series, it gives us the effect of intensity.

(273). By all the forms of medical machines, we obtain a current of intensity from a single voltaic battery: and thus we find that they are far more convenient to manage than a battery of high series. This result is obtained by a power of electricity, when passing through a wire, to develop a second current in a contiguous wire parallel to the first, and insulated from it. The second current is generated whenever the battery is either made or broken, but the direction of the current in the two instances is opposite.

(274). The simplest machine in which this phenomenon is manifested, is made by simply winding a stout covered copper wire of several yards in length into a coil, leaving the two ends to be connected with the two poles of a voltaic battery. If into the interior of the primary wire a piece of soft iron is inserted, so that it is magnetised by the voltaic power, the effects are greatly heightened, as we then add the force derived from magnetic induction to that produced by the simple induction through the wires. This machine is called the Primary Coil Machine.

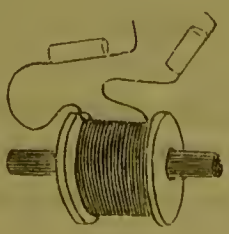


Fig. 15.

(275). The Secondary Coil machine is made by winding a second fine covered wire, of some hundred feet in length, in the same direction over the primary wire described in the last section, and leaving the two ends free to be attached to any object. Whenever the circuit is completed through the first wire, a current of strong tension is produced in the secondary. This current is in the same direction when the circuit is made, in the contrary direction when the circuit is broken. In this way we have by a rapid succession of the completion and rupture of the primary circuit, a rapid succession of currents in the secondary wire of a to-and-fro character.

(276). A modification in the construction of the medical machines may be made, by connecting one end of the secondary wire to one end of the primary wire, and then taking the shock from the extreme end of both wires combined. By this arrangement, the battery power has but a small length of thick wire to traverse, whilst the induced current is strengthened from its being also derived from the primary wire placed in close contact with the magnet.

(277). In using any of these machines, contrivances must be adopted for rapidly making and breaking the circuit, which is sometimes accomplished by mechanical means, as by the aid of a multiplying wheel, worked either by the hand or by clock-work. At other times, the same result is obtained by electro-magnetic means, as when a small electro-magnet is made rapidly to revolve between the poles of a permanent magnet. Perhaps, however, the most elegant mode to accomplish this object consists in using a piece of soft iron attached to a watch-spring, which vibrates with great rapidity under the action of the voltaic current, from the magnetic force acting upon the soft iron attached to the spring against its elasticity, and causing a rapid continuous vibration. When this latter contrivance is adopted, it is important that the points of contact should consist of solid platinum, fixed on without solder; for when solder is

used, the tin unites with the platinum, becomes oxydised, and rapidly ceases to act.

(278). For electro-therapeutics, or even for all purposes, it is advisable that the current should act in one uniform direction, and that it should not be a to-and-fro current, as ordinarily produced. Whenever an instrument is bought, this fact should be ascertained, which may be readily effected by finding whether metals are reduced from solutions of their salts, on only one of the platinum poles attached to the terminations of the wires.

(279). This unity of direction in a secondary coil machine, may be obtained by using contrivances to cut off one of the currents of the secondary wire. I have a machine of this character (fig. 16), constructed many years ago for me, in which it is so arranged, that when the first circuit is broken, the second is in continuity; when the first circuit is completed, the second is broken. This instrument forms an extremely valuable chemical and therapeutic agent. It has, however, the disadvantage of requiring manual or mechanical labour to cause the revolution of the wheel.

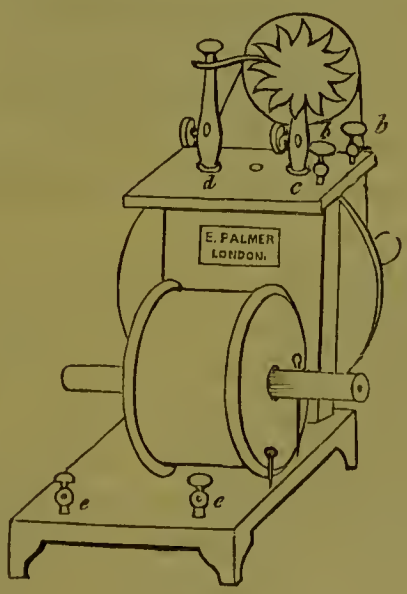


Fig. 16.

(280). Messrs. Horne and Thornthwaite have contrived a medical machine, which gives a single current upon the self-acting or watch-spring break. They employ a coil, in which

the primary and secondary wires are connected together, but have so arranged the terminations of the wires, that one of the currents in the secondary circuit is prevented from acting. They call their machine "The Electro-Galvanic Machine" (fig. 17),

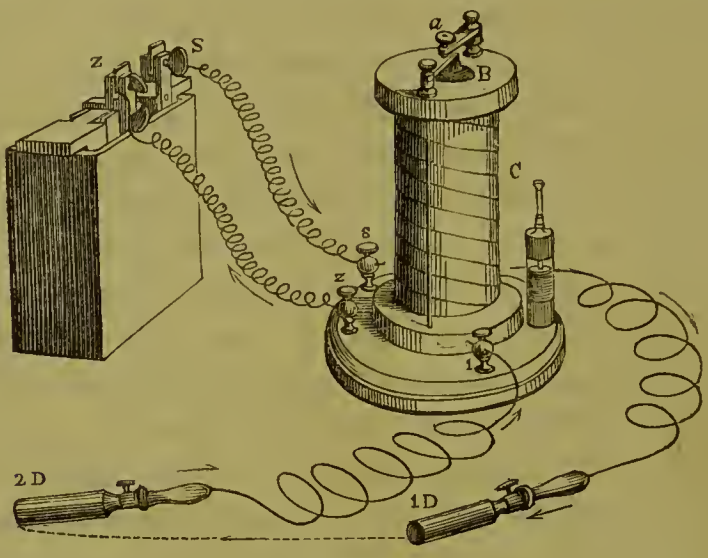


Fig. 17.

and, upon the whole, I think it to be the best contrivance of this kind which the surgeon can employ.

(281). All these various forms of machines give us intensity with but very feeble quantity; and, therefore, are safe in the hands of even the incipient tyro. They should always be marked so as to enable the patient to distinguish between the positive and negative poles.

(282). Whichever form of instrument be adopted, means should be employed to enable the operator to regulate the power of the induced currents. This end may be accomplished by increasing or decreasing the strength of the battery, by either adding more acid when we desire more power, or more water when we desire less. We may obtain the same result by exposing more or less of the platinised silver to the action of the fluid. In the coil, the power may be regulated by employing different lengths of wire, through which we obtain the induced electricity; for the longer the wire, the greater will be the power of the electrical force. We may also regulate the

power by the amount of iron constituting the electro-magnet; for, by withdrawing this, partially or completely, from the influence of the voltaic force, the induced current will be lessened. Lastly, a contrivance may be employed which effectually answers this purpose, by interposing a greater or less thickness of pure water, or any other imperfectly-conducting substance, in the course of the induced current. In some of the machines usually sold in the shops, several of these adaptations are applied to the same instrument (figs. 18, 19, 20).

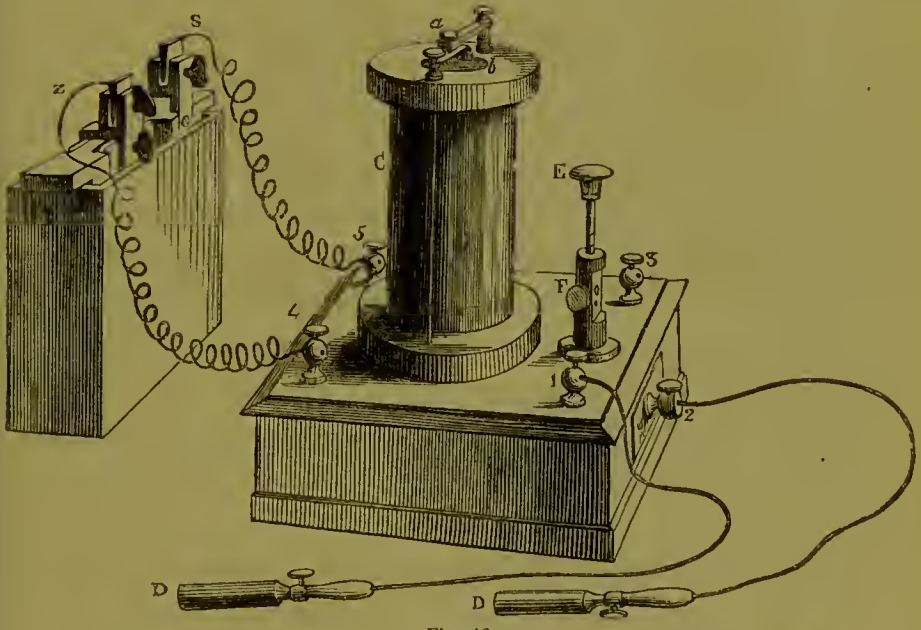


Fig. 18.

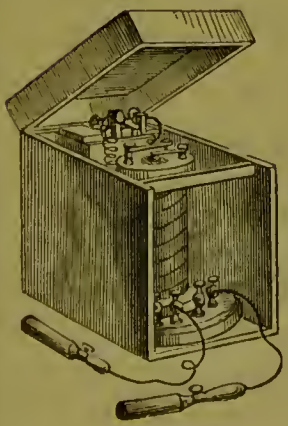


Fig. 19.

Fig. 20.

(283). The electricity set in motion from these machines, is distinguished by its small quantity and high intensity. It determines the action of the aisthenic pole of the peripheral battery. It also strongly stimulates the action of the dynamic pole, causing powerful contraction of the muscles. This form of electricity acts upon the capillaries, and produces redness, and perhaps may thus even influence nutrition, secretion, and excretion; but its practical application will hereafter be considered in minute detail.

MAGNETO-ELECTRICITY.

(284). Electricity may be derived from magnetism by using very powerful magnets, and revolving before them pieces of soft iron wound round with numerous layers of silk. According to the power of the magnet, the closeness of the approximation of the armatures, and the length and sizes of the wires, so do we obtain greater or less intensity or quantity of electricity by the revolution of the armatures.

(285). The magneto-electric apparatus (fig. 21) gives a

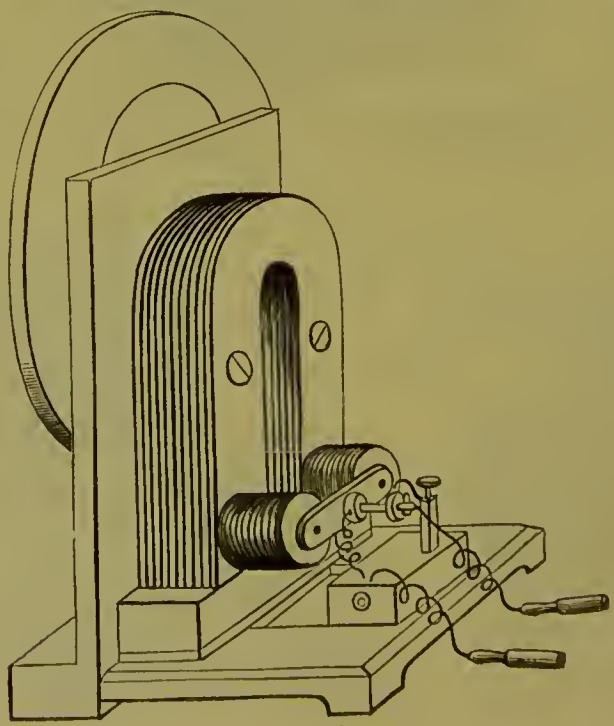


Fig. 21.

to-and-fro current, but it may be readily contrived so that every alternate current may be cut off. When thus arranged, it has been found to evolve so much electricity, that a patent has been taken out for the purpose of conducting electro-metallurgic operations by its influence.

(286). It is a curious fact, that although this machine gives an intermittent current it causes a constant deflection of a magnetic needle; so that, in its chemical effect, it is equivalent to a constant current, producing similar effects.

(287). The magneto-electric apparatus possesses an advantage in its not requiring the aid of a voltaic battery to set it in action. It is always ready, without any preparation, for the purposes of the analyst or therapeutist, in all weathers and at all times. Its only disadvantage is a trifling additional cost in the first instance, in consequence of the price of the permanent magnets, and it moreover requires a certain amount of power to keep its armature revolving.

(288). The power of the current can be adjusted to the greatest nicety, by regulating the distance between the armature and the magnets. Upon the whole, the magneto-electric machine is a most valuable electro-therapeutic engine; and either this, or the electro-magnetic machine, should be in the hands of every practitioner. The properties of the magneto-electric machine are precisely similar to those of the electro-magnetic machine.

MAGNETO-THERAPEUTICS.

(289). A supposition that magnetism can influence the body has existed for a long period. Pereira states that Œtius, who lived A.D. 550, mentions its application for the cure of disease. To ascertain whether magnetism was competent to act upon the capillaries, I placed the web of the frog's foot, and the tail of a fish under the microscope, and exposed them to the influence of very powerful electro-magnets without producing

the slightest effect upon the circulation of the blood. I have also subjected the various organs of sensation to the action of powerful magnets, but have not produced the slightest effect upon either the eye, ear, nose, tongue, or skin. From these experiments, we may safely infer that magnetism has either no influence at all, or but very little, on the functions of animal life. It is stated that Dr. Faraday allowed Dr. Keil to endeavour to affect him with powerful magnets, but without any result being produced.

(290). In this work I have demonstrated that the functions of animal life are really voltaic; and as there is no known method of either increasing or decreasing the action in the voltaic battery, by magnets placed near either the positive or negative pole, we cannot be surprised that the voltaic actions taking place in the body should also remain uninfluenced.

(291). I have not been more fortunate in obtaining positive results in my experiments upon cell life. I placed mustard-seed at different poles of the magnet, but I could not perceive that the growth at either pole was interfered with. The experiments are negative, and therefore are comparatively of but trifling value. I think the subject still deserves further investigation, for I should not be at all surprised to find some action, even if it be but trifling, on cell growth.

(292). Whilst recording a doubt upon the power of magnetism to affect the human frame, I ought to state that so distinguished an ornament of our profession as Laennec, declares that he has frequently relieved neuralgic pains in the lungs by the long-continued use of two magnetised plates, one applied at the back, the other on the front part of the chest. He also speaks most highly of the use of magnetism in angina pectoris, and even states that it has succeeded better in his hands than any other plan. Laennec further mentions that he has observed pimples, which are very painful, to appear at the anterior plate. It appears to me, however, that these effects would be produced by the plates even if unmagnetised, because I find that if any

part of the skin be covered up, so that no evaporation can take place therefrom, considerable irritation results. From all the above facts and experiments, we may safely affirm, that magnetism does not materially influence the organic or cell life, more than it does the animal or nerve life; and if this force has any action, it is almost inappreciable.

ELECTRO-THERMO THERAPEUTICS.

(293). Heat may be produced in two ways by electricity. In the first method, heat may be evolved by the disruptive discharge between the two poles of a voltaic battery, where disintegration is effected, and the particles of one pole pass over to the other, with the evolution of intense light, and great heat. It has been proposed to use this heat for cauterising; but it appears to me not so eligible as a plan presently to be noticed; and, moreover, it would require a long series of batteries, to effect the object in this manner. The second method of obtaining electric heat, is by passing an intense current through any part, either of the solid or fluid part of the voltaic circuit, when intense heat is produced. In this manner, if a powerful current be passed through a very small portion of fluid, it may be made to boil instantaneously, and thus produce unpleasant effects. I mention this, to caution the electro-therapeutist never to boil any part of his patient,—an effect which might readily be produced when large series of batteries are employed. This mode of generating heat does not appear to me calculated to be of utility for the cure of diseases.

(294). Heat is evolved when a certain amount of electricity is forced through a wire, which, from its small diameter, is incapable of conducting it quietly. This heat may be readily made to exceed that obtainable by any other process, except that of the oxyhydrogen blowpipe, as platinum may be made to run like wax by the electric force. The generation of a

high temperature by electricity, requires large batteries. Either two or three troughs of platinised silver batteries (fig. 22) may be used; or a series of the sulphate of copper (fig. 23), or nitric-acid batteries (fig. 24), or even the old Woollaston trough (fig. 25) may be employed for that purpose. This is the only instance

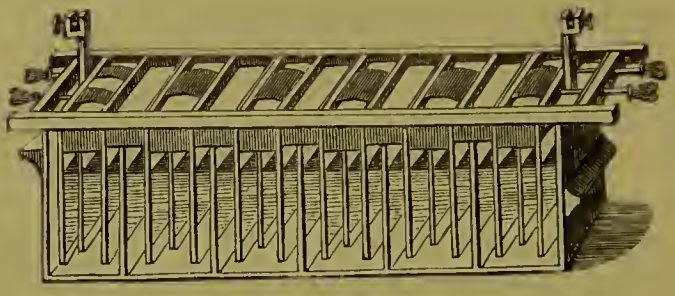


Fig 22.

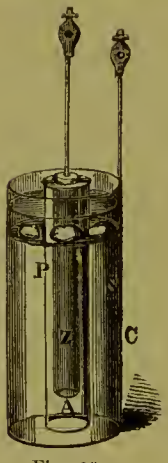


Fig. 23.

Fig. 24.

Fig. 25.

in which, I conceive, the surgeon can have any doubt as to the battery which it is advisable to select; and here, I believe, that the platinised silver battery will be found to suit his purpose best.

(295). There can be no question but that the electric cautery should supersede every other application of intense heat to the human frame. Its manageable character, by which the temperature may be raised to the nicest point; and its duration

regulated to the smallest fraction of time, gives it a very decided advantage over all other methods whatsoever.

(296). Inasmuch as the electro-thermal cautery may be of any magnitude, beginning with the finest platinum wire which Woollaston taught us to draw, it can be applied to all parts, and used under all circumstances. For instance, to stop the bleeding of a tooth when other means have failed; a bent wire might be introduced into the cavity, and the part instantaneously destroyed by passing the voltaic current through the wire.

(297). Again, if a platinum wire is coiled into a spiral, it may be heated to a white heat by passing a sufficient electrical current through it; and then it might serve the office of a cautery. Platinum wires might also be thrust through certain vascular growthsas nœvi, when the parts would be destroyed by passing a current through them.

(298). It is hardly my business at the present time, to point out each specific instance in which the electrical heat may be employed by the surgeon, for the medical practitioner should select such means as may enable him to obtain the desired result with the least inconvenience. In using electric heat, the only circumstance to be prevented is the fusion of the wires; this, however, may always be obviated, by trying the experiment with the same length of wire prior to its application to the human body.

ELECTRO-PHOTO THERAPEUTICS.

(299). The public were thrown into great excitement last autumn, by hearing that the electric light, produced by the disruptive discharge, would probably supersede all other modes of illumination. Success, however, entirely depends upon its cost, and this probably will prevent its extensive application for the purposes of mankind. The electric light

abounds in chemical rays, and thus approaches in some degree to the light of the sun, and perhaps would have some chemical effect on the body. There is only one use to which I conceive it might be applied by the surgeon, namely, to ascertain whether total blindness existed, as the intensity of the light is so great, that it would readily act through the partially opaque matters which usually veil sight.

ELECTROLYTIC THERAPEUTICS.

(300). Voltaic electricity decomposes all binary compounds. It resolves water into its elements, oxygen and hydrogen; and salts into their acids and bases. Various propositions have been made to use this property for the cure of disease; and I have seen recommendations to employ it for cataract, by inserting one needle into one part of the lens, and a second into another. Nothing but the most frightful ignorance could have dictated such a recommendation. I tried the experiment upon the eye of a perfectly healthy rabbit; the poor beast appeared to suffer the most excruciating agony. The ball of the eye was distended with gas on the application of the current; the cornea, in a few minutes, became quite opaque, and the whole eye was finally destroyed.

(301). It has also been proposed to attempt to coagulate the blood in an aneurismal sac upon electrolytic principles; but I can only regard such proposals as fraught with danger, in consequence of the disorganisation which experience has shewn is likely to ensue.

(302). In the electrolytic effects of the voltaic force, we must not forget the effects due to the development of acid and oxygen at the positive pole; of hydrogen and alkali at the negative. At the positive pole, or that pole connected with the silver of the battery, rapid disorganisation ensues, if the battery be sufficiently powerful. In this process vesica-

tion first takes place, after which the parts are destroyed. I have even observed a battery, consisting only of twelve cells, to disorganise the soft parts of a frog. It is, however, a painful process, and one not to be followed as a general rule. The electro-thermal cautery would be far more rapid in its action, and less painful.

(303). This power of disorganisation, however, should be borne in mind; and perhaps in certain cases of indolent ulcers it might occasionally be turned to good account. For electrolytic purposes, the Electro-Therapeutic battery, of from ten to fifty small cells, should be used.

THERMO-ELECTRO-THERAPEUTICS.

(304). To take a comprehensive view of Electro-Therapeutics, we must not confine our attention alone to the method in which the various forms of electricity may act upon the voltaic currents in the body, but we must consider how far other agents may produce a similar action. To enter into such considerations, the detail would much exceed the limits which I have assigned to myself in this treatise, and therefore I shall but very briefly advert to them.

(305). Of all agents which act upon the human frame, perhaps, variations in temperature produce the most potent results. Heat and cold are great surgical weapons, with which most extensive results may be produced. In all voltaic arrangements, we find that heat increases the action, cold retards it. In Electro-Metallurgic operations, the difference between summer and winter is strikingly exemplified; and when hot weather has suddenly set in, I have been frequently inundated with letters from all parts of the country soliciting information, as the operators found that their processes had run wild.

(306). From these experiments it follows, that the phenomena of animal life which depend upon electric currents are

entirely controlled by heat and cold. Heat first excites, then exhausts the powers of the part on which it acts; cold depresses them at last to total inaction. As in the voltaic battery sufficient cold will always stop action, so in the human body deficiency of temperature will cause the cessation of feeling, and even of life itself. Cold is extremely valuable in causing sleep; and a cold cloth to the top of the head, or the application of cold water over the body till chilliness is produced, will produce sleep after all narcotics have failed, or under circumstances when they are inadmissible. The most violent paroxysms of hysteria and insanity have in my hands yielded to cold applications, when other means have been tried and failed.

(307). The influence of temperature on cell life is equally conspicuous, as we find that each plant and each animal has a certain temperature at which it best thrives; and that any deviation therefrom interferes with its nutrition and growth. Inasmuch as we are but ill acquainted with the forces of cell-life, it is uncertain whether these results are due to the influence on electrical currents.

(308). Variations in temperature act powerfully upon the whole bio-dynamic circuit;—they influence the aisthenic pole, or all the organs of sensation: they influence the dynamic pole, or the entire muscular system: and lastly, they have important effects on pain, delirium, inflammation, rheumatism, and all other diseases in which the electro-nervous power is concerned.

PHOTO-ELECTRO THERAPEUTICS.

(309). The light of the sun may determine certain voltaic combinations, which I have described under the term of "Photo-Voltaic Circuits." Light stimulates to action the aisthenic pole of the peripheral battery; and for the eye, or opsaisthenic pole, it is the normal stimulant. Light also seems to affect the cell-life of animated beings. Some time since, I crossed the

Furca pass in Switzerland, one intensely bright day in the middle of June, with two or three parties, composed of persons from different nations; and the next morning, I observed that the skin was peeled from the face of every tourist but myself. Light also tends to the production of the *coup de soleil,* of which I have seen only a solitary instance: this is another example of the effect of light upon the body.

(310). An absence of light causes persons so deprived to evince certain peculiarities; and when confined in dungeons, cellars, or in the dark courts of London, they become blanched or etoliated, like celery, endive, or lettuces, on which light is not allowed to act.

PSYCHO-ELECTRO THERAPEUTICS.

(311). As we may affect the electro-biological circuit by physical forces acting upon the peripheral battery, so may we also produce an influence upon man by impressions acting upon the central batteries. In proportion as these impressions influence the higher batteries, so are the effects more exalted. From this cause, moral emotions produce great effects upon the body, and frequently cause instant death. Pettigrew has collected many curious cases, where joy, grief, or rage, has instantly exhausted the electro-biological circuit, and caused death.

(312). These cases form extreme instances of the action of psycho-electric impressions. Upon the whole, to act upon the body through the medium of these impressions, is a thing generally to be avoided by the medical profession. Nevertheless, the value of our art is greatly enhanced by holding out, on the one hand, every fair hope; and, on the other hand, by making the patient understand the results which probably he has to fear, where he shews a tendency to neglect himself. In every instance, a psycho-therapeutic impression should be within the strictest bounds of truth.

(313). I need hardly notice that diet, exercise, climate, and the use of various medicines, must have very important bearings upon the supply of matter to the body in keeping its voltaic batteries duly charged. In many instances, however, the working operation of any specific material is quite unknown, and not even the vaguest theory can be assigned for the mode of action of any particular agent.

(314). The great influence of diet is doubtless to supply proper materials for the body through the blood. Food, however, has to provide for cell-life, as well as the electro-life,—a circumstance which must be considered. After a severe loss of blood, the functions of animal life are suspended, and cannot be performed. In this instance, we obtain good results from charging the batteries, by the process of transfusion, with blood drawn from another individual. I know two or three cases in which life has been preserved by this proceeding. The blood should be selected from the same animal, the same sex, and if possible, from the same family.

(315). The use of water, either in excess or scarcity, will also act a very important electro-therapeutic part. In a voltaic battery, its relation to the exciting material, or acid, regulates the action of the battery; and a different effect is produced when the water is added little by little, and when it is added at once. An excess of water suddenly taken into the blood causes instantaneous death; and it is said, that Alexander the Great lost more men from drinking cold water, than ever he lost in one day in battle.

(316). The action of the wind has a very decided electro-therapeutic effect. In high gales, great pressure is made upon the whole surface of the body, and the aisthenic pole is thereby excited to action.

(317). Pressure, friction, especially by coarse towels and

horse-hair gloves, has a very decided effect in producing electro-therapeutic effects; and there is no method better adapted to excite the aisthenic pole, than brisk friction.

(318). By taking a cursory view of the entire subject of electro-therapeutics, we perceive that it is a contracted and erroneous notion to suppose that the electro-biological circuit is alone influenced by electricity. All forces have their origin in change of matter, and this change of matter may be ultimately resolvable into a new attraction between its particles. We thus perceive, that all material forces have one common origin, and that each may influence the voltaic currents existing in the body; and, whether the force be that of light, of electricity, of heat, or of ordinary power, it will, under certain circumstances, determine the action of the peripheral batteries in the human body.

Fig. 26 .

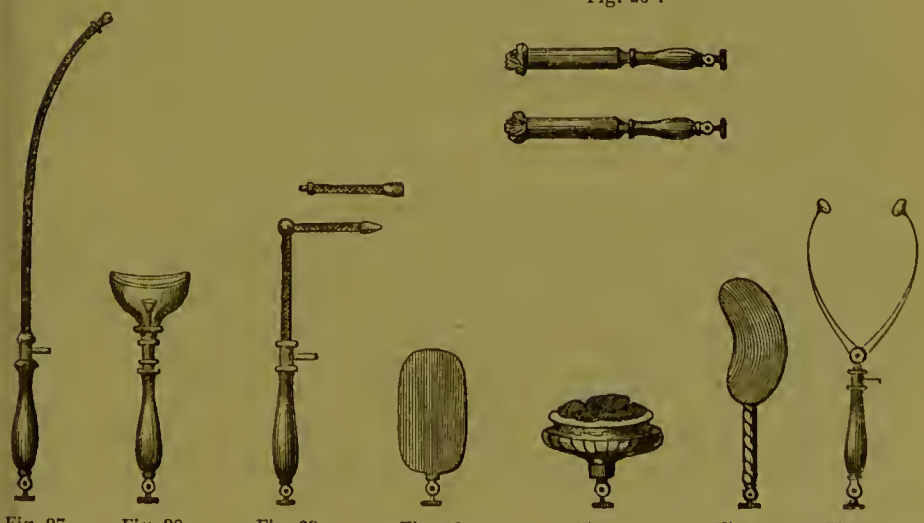


Fig. 27. Fig. 28. Fig. 29. Fig. 30. Fig. 31. Fig. 32. Fig. 33.

INSTRUMENTS USED FOR THE APPLICATION OF ELECTRICITY.

CHAPTER ELEVENTH.

ON THE DETECTION OF NEEDLES AND OTHER STEEL INSTRUMENTS IMPACTED IN THE BODY.

319. Needles, etc. in the Human Body. — 320. Difficulty of discovering. — 321. Case of Impaction detailed. — 322. Magnetising the Impacted Steel. — 323. Apparatus for Magnetising. — 324. Form of Battery. — 325. Part where the Electro-Magnet is to be applied; selection of. — 326, 327. Application of Magnet. — 328. Formation of Polarity in Impacted Steel. — 329. Magnetic Needle for Testing. — 330. Operation of Testing. — 331. Precautions necessary. — 332. Remark. — 333. Observations. — 334. Operation for Extraction. 335. Concluding Remarks.

(319). During my surgical lectures in the session 1844-45, I first made known a plan which I had successfully employed for the discovery of the situation of needles and other steel instruments impacted in the human frame. Every surgeon is constantly consulted upon these cases; and the patient, not unfrequently, is uncertain whether a foreign body has actually penetrated his flesh, or cannot confidently point out its exact situation. In these cases, a continual pain occurring after a prick, is commonly the only cause for his supposing the presence of a foreign body in the system.

(320). The surgeon may carefully examine the suspected part, and yet, it often happens, that after the utmost scrutiny, he can speak with no more certainty, either of the existence or of the situation of the foreign body, than his patient; for,

although a piece of needle, an inch in length, may be actually imbedded under the skin, the most skilful surgeon may be unable, by any manipulation, to ascertain its presence.

(321). We need not now remain long in this state of uncertainty, for there are means by which we may readily and effectually ascertain the presence or absence of any particle of steel or hard iron. The plan which I have to detail, occurred to my mind from having a sempstress under my care, who, unfortunately, had pierced one of the joints of her fore-finger with a piece of a needle, which had firmly imbedded itself in the bone, and then snapped off. This piece weighed only the sixth of a grain, though it subsequently caused the destruction of the joint, and amputation was only averted by using the utmost care to procure anchilosis. I had no means, at that time, of ascertaining the presence or absence of the needle:—I could not feel it, nor was the patient certain that she had received more than a severe prick at that part.

(322). To detect needles, or any other fragments of steel or hard iron, we take advantage of the well-known laws of magnetism. For this purpose, we magnetise the imbedded fragment, or rather, subject the part suspected to contain steel, to such a force as is competent to convert the iron or steel, if present, into a magnet. This may be done in several modes; for, whether we magnetise by means of a voltaic circuit, an electro-magnet, a permanent magnet, or a loadstone, it matters but little, provided we magnetise, as powerfully as possible, the enclosed object.

(323). I myself prefer, and generally employ a strong Electro-Magnet (fig. 34), consisting of a bar of soft iron, about

Fig. 34.

three-eighths of an inch in diameter, wound round with wire.

The iron has a plate of brass (B), fixed on both ends to retain the wire (*w*) *in situ*, and the two ends of the wire are attached to binding screws (*s s*), to connect it with the voltaic battery.

(324). Any form of battery may be employed to render the iron magnetic. I use from one (fig. 35) to twelve cells (fig. 10, p. 87)

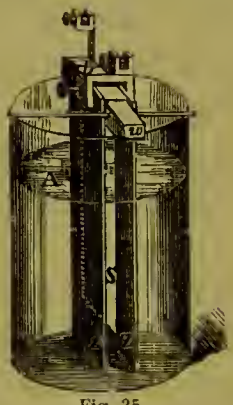


Fig. 35.

of my own form, increasing the number according as I desire to render the magnet more powerful, and to perform the operation more expeditiously.

(325). The Electro-Magnet is to be placed in contact with the skin over the suspected part, and we should select a situation where a possibility of its existence is indicated.

Sometimes we regulate our choice of the situation from the patient feeling some uneasy sensation in a particular spot; at other times the patient will complain of the functions of the part being more or less injured. Occasionally a swelling will give rise to suspicion; and, lastly, the existence of a small mark on the skin, like that of a puncture, will determine the surgeon in his choice.

(326). When the surgeon has chosen his locality, he places the Electro-Magnet exactly over the suspected place for about a quarter of an hour, which, if a powerful battery be used, will generally be found sufficient to induce strong magnetism in the imbedded needle. The most favourable situation for magnetising a needle with a strong Electro-Magnet, is that at which one end is acted upon by the instrument.

(327). After this process has been followed, the part may

be tested for magnetism in the manner in which I shall presently describe; and, if no indications are presented, other spots may be tried. In fact, every part of the body might be subjected to experiment, were it not that the patient would be fatigued, as well as the surgeon, by the tediousness of such an extensive examination.

(328). By the last described means, the imbedded needle is converted into a magnet, and has therefore a north and south pole. These poles have the property of attracting unlike, and of repelling like poles of another magnet. From this peculiarity, we can not only ascertain the presence of magnets, but are even able to learn the position of the two poles of the fragment. It frequently happens, that the impacted portion is magnetised before insertion into the body, and steel pens, needles, knives, etc., are always found to possess more or less magnetism. In such instances, no process of magnetism is required.

(329). To test for magnetism, a magnetic needle is required. On several occasions I have been contented with a magnetised sewing or ladies' knitting-needle, suspended by a film of thread, though I now more usually employ a needle about six inches long, centered upon a small agate cap, resting upon a steel point, which is fixed on a brass stand (fig. 36).

Fig. 36.

The needle should be so arranged, that the smallest possible amount of resistance is offered to its free play.

(330). The suspected part is brought near one pole of the magnetic needle, when, if it contain no magnet, no effect will

be produced; but if there be one present, certain indications will be observed, differing according to the position of the magnet in the body with regard to the pole of the magnetic needle. If the impacted needle be either above or below the magnetic needle, it will only cause it to exhibit agitation; and if the centre of the imbedded fragment be brought near the needle, but little effect will be produced. By gently moving about the suspected part, however, the test-needle will become attracted as soon as the opposite pole of the fragment is approximated to it. The point of greatest attraction indicates the position of one pole of the encased magnet. By moving the suspected part gently about, the operator will at length find the point of repulsion, which indicates the other end of the needle. The surgeon may test the accuracy of his observations, by repeating the experiments with the opposite pole of the test-needle, when the part which caused attraction before will now cause repulsion; the point which caused repulsion, attraction.

(331). To determine the presence, exact situation, and direction of a small piece of steel, patience and skill are frequently required; and the surgeon must be careful to guard against fallacies arising from currents of air caused by breathing, or even at times by the heat of the part subjected to the magnetic test.

(332). I have myself detected, and subsequently extracted several pieces weighing about one-tenth of a grain; and from experiments I have made, I believe it would be possible to extract fragments weighing from the one-sixtieth to the one-hundredth of a grain. Of course, the larger the piece of needle, the easier would be its detection.

(333). After the needle has been magnetised, it will in some cases permanently retain its magnetism. For this reason we need not hurry ourselves to test for magnetism, as in different cases we may repeat our observation for two or three days, in order to ascertain with great exactness the precise spot in which the foreign body is impacted. In other cases

the steel will lose this acquired property, when it will be necessary to re-magnetise it, in order to test its presence. In all instances, I would particularly urge the propriety of a most thorough search by means of the test needle, as the surgeon will never have cause to regret the time as mis-spent in this part of the operation. When the test gives negative results, it requires a long and scrutinising research, before we can inform our patient decidedly that no needle is imbedded in his body.

(334). When positive evidence is obtained of the presence of the foreign body, the surgeon may at once proceed to remove it by incision. Although the operation in itself is generally trifling, unless the needle is imbedded near some vital part, it requires tact to regulate the direction of the incision, if the surgeon hopes to remove the needle. The incision, in all cases, should be made sufficiently deep at one cut, and of a length rarely less than three-fourths of an inch. The direction of the cut is sometimes best made from one magnetic pole towards the other; and at other times the needle will be more readily found, by cutting a little transversely to the axis of the magnet.

In many instances the surgeon will at once find the needle, and be able immediately to extract it with a pair of forceps. In some cases, however, even though the surgeon goes through all the necessary processes with the utmost care, he will not succeed in finding it at one cut; in which case he need not pursue his research farther, because if the cut is made directly over the inclosed fragment, it will generally be speedily thrown out when suppuration is well established. When the surgeon conceives that there is reason for not performing the operation, or when, from any cause, he wishes its delay, the test may be occasionally used to ascertain whether it remains in the same place; or whether, as is the habit with needles, it is making a tour to a more distant part of the body. By the magnetic test we can always know the locality; in fact we

can, with our mind's eye, see that which is invisible to the direct organs of sense.

(335). My experience of the efficacy of the magnetic test for the detection of needles and other steel instruments, leads me to form the highest opinion of its importance in all cases where the object is not to be felt, or its existence ascertained by more direct means. The test, when it gives positive indication, is, so far as I know, infallible. When, after a careful search, we get no evidence, we may safely infer the non-existence of the suspected object. The negative evidence, nevertheless, is not of the same value as the positive. Now that magnetism can with certainty be used to ascertain the locality of steel fragments, no surgeon will be justified in attempting at random to make an incision to extract a needle, when he is uncertain of its exact situation, before he has submitted the suspected part to the magnetic test.

CHAPTER TWELFTH.

ELECTRO-PATHOLOGY.

336. Electro-Pathology: Subdivision of the Subject.—337. Diseases arising from alterations in the blood: Classification of.—338. Electro-Pathology of.—339 Obstructed Circulation in Capillaries.—340. Exudation and Imbibition: Dropsy.—341. Treatment of: Endosmosis and Exosmosis.—342. Hæmorrhage, without division of Vessels.—343. Hæmorrhage from divided Vessels: Electric Treatment of.—344, 345. Atrophy and Hypertrophy.—346. Reparation: New Growths.—347. Ulcer: Ulceration.—348. Cicatrization.—349. Pathology of Inflammation.—350. Relation with Electricity considered.—351. Fever.—352. Rheumatism: its Characteristics: Acute form: Effect of Electricity in the Chronic form.—353. Scrofula and Phthisis: Tubercle: Electric Relation.—354. Cod-Liver Oil: Action of, in Tubercular Diseases.—355. Cancer.—356. Syphilis.—357. Glanders.—358. Cysts.—359. Entozoa and Parasites.—360. Diseases of Sensation.—361. Anæsthesia: Employment of Electricity in.—362. Neuralgia: Electricity and Aconitine.—363. Diseases of Vision.—364. Use of Electricity in.—365. Deafness: Morbid Acuteness of Hearing.—366. Diseases of Smelling.—367. Of Taste.—368. Patho-Dynamics.—369. Tonic Spasms.—370. Electricity, Ether, Chloroform.—371. Hydrophobia.—372. Cramp.—373. Cough, Sneezing, Hiccup, and other Clonic Spasms.—374. Chorea: Electrical Treatment.—375. Trembling, etc. etc.—376. Electro-Patho-Noemics: Disease of Memory.—377. Idiotcy.—378. Giddiness.—379. Delirium: Delirium Tremens.—380. Insensibility: Use of Electricity.—381. Desire for Action: Relation to Crime.—382. Insanity: Phreno-Aisthenic Battery.—383. Syndramic Battery.—384, Erroneous Action of other Batteries.—385. Aisthenic-Noemics: Syndramic Noemics.—386. Other Instances: Phreno-Aisthenic Battery.—387. Action from False Impression.—388. Controlling Effect of Moral Impression.—389. Management of Lunatics.—390. Lesser Mental Derangements.—391. Voltaic explanation.—392. Over-work of Brain.—393. Absence of Mind, Sleep-walking, etc.—394. Fits.—395. Epilepsy: Nature and Treatment of.—396. Coma.—397. Fainting.—398. Hysteria.—399. Collapse.—400. Indigestion.—

401. Employment of Electricity in. — 402. Amenorrhea. — 403. Use of Electricity in. — 404. Barrenness. — 405. Uterine Inertia. — 406. Uterine Bleeding. — 407. Asthma. — 408. Asphyxia. — 409. Abnormal State of Secretion and Excretion. — 410. Relation of Electricity to the Kidneys, Liver, and Alimentary Canal. — 411. Collapse from Cholera, — 412. Functions of Skin. — 413. Electricity compared with other Remedies, generally. Conclusion.

(336). In studying the electrical relations of diseases, we find that they are presented to our notice under several heads Firstly, we have diseases of the blood, or exciting fluid of the electro-biological circuit; secondly, we have diseases of the central and peripheral parenchyma and of the nervous media, which serve as telegraphs to connect them together: we have then to study the electric relations of growth and nutrition with the abnormal tissues and products occasionally produced: and we have lastly to study the deviation from the usual actions of health.

DISEASES OF THE BLOOD.

(337). The researches of modern chemists have done much to elucidate the pathology of the blood. This material is liable to various important alterations, and perhaps the classification of these adopted by Simon is to be preferred. He separates them into four classes: in the first class (hyperinosis) the fibrin and fat are increased, — the corpuscules diminished: this state is observed in pleuritis, peritonitis, nephritis, carditis, acute rheumatism, erysipelas, phthisis, puerperal fever. In the second class (hypinosis), the corpuscules are increased, the fibrin diminished, a condition which is found in typhus, continued fever, small-pox, scarlet fever, cerebral hæmorrhage. The third class (spanæmia), comprises cases in which both the fibrin and corpuscules are less, whilst the water is increased: this condition is observed in anemia, carcinoma, scrofula, chlorosis, scurvy, yellow fever, and plague. The last class (hetrochymeusis) embraces those instances in which new matters are

contained in the blood; as, for instance, uræmia, where urea is found in the blood, which is the case in Bright's disease, and in cholera, etc. Sometimes bile is found in the blood, which is termed cholæmia. Occasionally fat, or even animalculæ, may be detected; and under certain circumstances, a great variety of other matters may be detected in this fluid.

(338). In all these cases, the blood is actually altered in quality, and therefore its power to effectually charge the batteries, and to enable them to perform the various vital functions in a healthy manner, is also altered. There is no known method, however, by which electricity can be brought to bear, to alter any of these states, which are manifestly electro-pathological.

IMPERFECT DISTRIBUTION OF THE BLOOD.

(339). Healthy arterial blood should be regularly and equably distributed throughout all the capillaries of the body. It frequently happens, however, that it leaves one part and engorges another. From experiments detailed in a former part of this book, it was shewn, that the circulation through the capillaries is materially influenced by electrical currents; and hence, we have aright to conclude, that these arrangements are influenced by the ordinary voltaic currents which exist in the electro-biological circuit. In these cases, the line of treatment indicated, is to equalise the distribution of blood by drawing it to remote parts which are unsupplied. Perhaps electricity might be beneficially employed; but the agency of heat and cold in some instances, and of friction in others, produces results which, acting upon electric principles, are sometimes preferable to the immediate influence of electricity itself, and may be regarded in every way, as electro-therapeutic. In a former chapter, I have demonstrated the important influence of electricity on the capillary circulation.

DROPSY.

(340). Besides the circulation of the blood in the capillaries, there appears to be an exudation and imbibition, by which the fluid passes out of the vessels and lubricates various tissues, which thus receive the material by which they are nourished. In some instances, the fluid becomes more watery, and is not again taken into the capillaries, giving rise, when it is left in the cellular tissue, to œdema,—in the peritoneum, to anasarca,—in the pleura, to hydro-thorax,—in the pericardium, to hydro-pericardium,—in the tunica vaginalis, to hydrocele,—in the ventricles of the brain, to hydrocephalus.

(341). This exudation and imbibition is perhaps perfectly explicable upon the laws of endosmosis and exosmosis; and it is unknown whether voltaic electricity can either increase or decrease these effects. Any electro-therapeutic agent might cause more blood to be supplied to the part, and thus perhaps help, to a certain extent, the cure of this affection, though our treatment for these maladies is directed to the removal of the water from the blood, by excreting it from the kidneys, intestines, or skin. By thus inspissating the blood, the fluid is absorbed upon the known laws of endosmosis and exosmosis. In most dropsical diseases, not only is the relation of water to the solid materials altered, but perhaps the composition of both blood and serum is also altered in some other respects.

HÆMORRHAGE.

(342). Bleeding may take place, according to the belief of some pathologists, without the actual laceration of the vessels themselves, in which case the bleeding is called "Medical Hæmorrhage." This is seen in bleeding from the lungs, or Hæmoptysis; in bleeding from the nose (Epistaxis)—in

Purpura, and other disorders. In all these cases, there is either a vitiation of the qualities of the blood, or an irregular distribution. Electricity has not yet been applied with benefit in such cases.

(343). Where blood-vessels are actually divided, the bleeding is denominated "Surgical Bleeding"; and upon this, electricity might be brought to bear with advantage through its property of disorganisation, as in Electrolytic Therapeutics; or by its property of generating heat, as in Electro-Thermo-Therapeutics. In these cases, the neighbouring parts are destroyed, the arteries clogged up with lymph, and thus the bleeding is prevented. Electro-thermo-therapeutics may be frequently used as a valuable surgical appliance, when other means could not possibly be employed.

ATROPHY AND HYPERTROPHY.

(344). Both an imperfect and excessive nutrition are states frequently observed. In neither case, however, as a general rule, do they appear to be owing to voltaic causes. The nutrition of some tissues is subservient to their employment, as muscle wastes when disused, and grows when much employed. In these cases, the nutrition appears directly owing to voltaic effects; and hereafter, I shall demonstrate that it is really promoted by the agency of electricity. In other instances, as in the nutrition of bone, no such cause is to be found, as osseous tissue neither increases nor decreases with a corresponding variation of the exercise.

(345). Various parts of the body are preternaturally increased or decreased in their first development, which is similar to Atrophy and Hypertrophy. In the diminutive Tom Thumb, and in the gigantic O'Brien, we have instances of general variations from the proper standard. Neither state, as far as we know, is influenced by electricity; nor does it appear

probable that the electro-therapeutist can in any way regulate the matter.

REPARATION.

(346). After injuries to the body, either from external actions, or from internal diseases, new growths occur, and reparation ensues. These changes differ but little from the original development of the organ, as reparation is always produced by cells, like those observed in original formation; and the same uncertainty exists with respect to the share which the electro-biological currents have on their arrangement. It is true that electricity may be used advantageously through its chemical or thermal powers, and even by its capacity to stimulate the capillaries. In these instances, its action would be secondary, and no direct effect of electricity would be shewn upon the cells themselves.

ULCERATION.

(347). The term, "Ulcer," is assigned to any breach of surface in the body, whether caused by any external force, or internal disease. Whether the destruction or removal of the portion of the body arise from heat, force, chemical or irritating agents; or whether it be taken into the system by absorption, the unhealed surface where the gap exists is termed an Ulcer. When we speak, however, of ulceration, we imply that a portion of the body is being removed by absorption; and that the materials of which it was composed are being taken into the system.

(348). Before an external ulcer heals, cytoblastema is deposited, in which cells are formed. These first give rise to granulations, which, as soon as they become level with the adjacent parts, are covered with a persistant membrane, which process is called "Cicatrisation." I need hardly again repeat the relation of electricity to reparation. But in all

states of ulceration, we should bear in mind the electrolytic, the thermal, and the stimulating power of electricity, which may be directly applied in all cases where the healing process is imperfect. In each individual instance, the surgeon must be guided according to circumstances, in the preference of electricity to other means of obtaining the same results; and of course he would choose that which he might deem most effectual, and most easy of application.

INFLAMMATION.

(349.) Inflammation may be defined to be an abnormal action of the body, tending to the formation of pus. Now, pus is an organic cell, which differs from the ordinary cells of which the body is built up; and the same obscurity which appertains to the electro-physiology of ordinary cells, appertains also to that of the pus corpuscule. When inflammation occurs, we have an increase of temperature, greater vascularity, a deviation in the ordinary sensation, amounting generally to absolute pain, and a greater or less impairment of the ordinary functions of either the aisthenic or dynamic poles of the peripheral battery. From these results, it is apparent that inflammation involves the electro-biological circuit. Adhesive lymph occurring in connection with inflammation, has been proved by modern pathologists to contain, in all cases, pus corpuscules.

(350). Whether, conversely, electro-therapeutics can benefit inflammation, is a question now to be considered; and the application of cold to prevent inflammation; of heat, by poultices, fomentations, and like appliances to exhaust it when it actually has occurred, may be perhaps regarded as thermo-electro-therapeutic influences. The direct influence of electricity upon this disease has not yet been ascertained, though no surgeon can well doubt, that in the chronic, indolent forms, it may be used beneficially as a stimulus. For this purpose, the electricity should be derived from the electro-magnetic, or magneto-electric apparatus.

FEVER.

(351). The essential character of Fevers is perhaps less understood than that of inflammation. The total absence of feeling and motion in severe cases, indicates a great derangement of the functions of the electro-biological circuit. I have already mentioned that the blood is greatly at fault in fevers, which sufficiently accounts for the cessation of the functions of the electro-biological circuit. We do not know whether the diseased state of the blood is the primary cause of the phenomena of fever; or whether other changes are taking place in the nutrition of the body, through the cells of which it is composed. Lastly, we are ignorant whether fever is a malady in which the electro-biological actions are alone at fault. In this uncertainty, we cannot judge of the relation of electricity to fever; nor can we pass any opinion upon the possible benefit of electricity, used in any manner as a curative agent.

RHEUMATISM.

(352). Rheumatism may be defined to be an abnormal action, with the excessive formation of lithates. It is distinguished from inflammation by the difference of the character of the new matters, by the excessive pain which it causes, and by its tendency to shift suddenly from one part of the body to another. From these considerations, it appears to be a disease which rather appertains to the Electro-Biological circuit, than to the cell-life. Rheumatism may therefore be classed under Electro-Pathological states. Before we can employ electricity for its treatment, it is either necessary to remove the excess of lithates, by acting upon the kidneys by the salts of potash, sweet spirits of nitre, or other similar remedies; or to stop the morbid action by colchicum, which

has an influence on the disease upon some unknown principle. In Chronic Rheumatism, however, when these results have been obtained, electricity presents itself to our notice as an invaluable auxiliary to our treatment. I have frequently seen it remove old standing diseases about the joints, when other remedies have failed to be beneficial. It should be employed daily from ten minutes to half an hour, and as much electricity should be used as the patient can comfortably bear. The Electro-Magnetic, and Magneto-Electric machines, are best adapted for this purpose. One pole should be applied to the sole of the foot, or palm of the hands, whilst the other is moved all over the skin of the limb, especially near the affected parts, to excite all parts to action.

SCROFULA, CONSUMPTION, ETC.

(353). Scrofula, Consumption, and other diseases emanating from the production of tubercle, differ remarkably from Rheumatism and Inflammation, inasmuch as they exhibit a deviation of the normal cell-life with but little variation in the action of the Electro-Biological circuit. In these maladies we observe a great amount of organic disease, accompanied with very little pain, very little impairment of the power of motion, or other functions of the diseased part, compared with the impairment which would have been produced with the same amount of change in Inflammation or Rheumatism. Scrofula, in its widest signification, may be defined to be an abnormal action, with the production of tubercular matter. Tubercle is an organic cell which is produced under certain circumstances, and is generally accompanied by the absorption of the ordinary material of which the cells are built up. If we suppose that tubercular cells obey the laws of the normal cells of the body, we find that it is highly doubtful whether the voltaic currents in the body influence their development

or growth to any great extent. From these considerations, we may question the utility of using electricity as a remedial agent for these growths. As a matter of experience, we find that it is advisable to regulate the action of the asthenic pole in these cases, by applying friction to the skin, or exposing it to the influence of light or radiant heat. On this account electricity must act beneficially as a similar stimulus to these parts, though I have not found it sufficiently advantageous to employ it, except in cases where the patient himself has desired it; and even in such cases it should never be allowed to cause any distress.

(354). The beneficial action of cod's-liver oil in these cases may possibly, in part, depend upon its influence on the asthenic pole, in which situation it is manifestly deposited in the form of fat. I have frequently watched, with intense interest, the disappearance of large masses of tubercular matters during its administration, when every known line of treatment had failed. This absorption, however, we may expect to be due to other causes than its influence on the asthenic pole; and perhaps, in these instances, it may traverse by imbibition, or give to the serous portion of the blood a power of traversing the non-vascular parts, and thus enable abnormal matter there deposited to be absorbed.

CANCER.

(355). Cancer, like scrofula and inflammation, consists of an abnormal organic cell, which, however, differs from both tubercle and pus in its physical characters. It is doubtful whether electric currents tend to its production, or whether the application of electricity can favour or prevent its growth. I have occasionally met with females who declare that cancerous swellings have been dispersed by its agency; though I myself am inclined to believe that the party who named the malady erred in judgment, and mistook for cancer some trifling induration of the mammary tissue, which occurs in young females.

SYPHILIS.

(356). The syphilitic virus consists of an abnormal organic cell, which influences the entire cell-life of the body. It appears to have no relation to the voltaic currents, nor has electricity been employed successfully for the treatment of the malady.

GLANDERS.

(357). This disease, which only occurs in man from having derived infection from a horse, consists probably of an abnormal cell, similar to that of Syphilis, and therefore of doubtful electrical relation.

CYSTS.

(358). Cysts constantly occur as a diseased production; and sometimes they contain hairs, teeth, or other matters. They appear to be a phenomenon of cell-life exclusively.

ENTOZOA AND PARASITES.

(359). The occurrence of Entozoa throughout the various parts of the animal economy, certainly presents most remarkable instances of generation. Their occurrence should cause us to weigh deeply the value of electricity in favouring the development of living creatures; for, certainly, the presence of some of these creatures is totally unaccountable upon any probable hypothesis. Some time ago, a patient of mine had a most unruly tapeworm, which would not be killed by processes amply sufficient to have destroyed abundance of other creatures of a similar class. As the patient had already received

the very best treatment from able surgeons, and had also tried every line of treatment under my care, I determined to apply electricity, with the view of destroying it. For this purpose, the current was passed from the internal parts of the anus to the surface of the stomach; and we employed as much force as the boy could possibly bear, continuing the operation for a short period on several occasions. A few joints of the worm came away subsequently; but, in my opinion, no more than what might be accounted for upon other hypotheses. This case was tried some years ago, and the to-and-fro current was employed; and, therefore, if the experiment were repeated upon a similar indestructible worm, it might be as well to use the electro-magnetic and magneto-electric machine. As this mode of employing electricity is attended with considerable pain, it would be folly to think of using it till other known modes of cure had failed. With respect to other Entozoa, or Parasites, I know no other instance where electricity has been used for their destruction.

PATHO-AISTHENICS.

(360). We have now to consider a part of the subject which is purely electro-pathological; for, inasmuch as the mechanism of all sensations is voltaic, the pathology of the same functions is voltaic also. Diseases of sensation come under our notice in all cases, where the normal reception of impressions from without is either increased, decreased, or totally prevented. They all have a somewhat similar origin, as they originate from causes emanating from the structure of the aisthenic organ itself, from a variation in the supply of blood to that organ; or from causes existing in the phreno-telegraphs, or nervous communications. Moreover, the causes may exist in the central batteries, or brain itself; and lastly, in some rare cases, the opposed pole in the peripheral battery may possibly be the source of mischief.

ANASTHESIA,

LOSS OF COMMON SENSATION.

(361). Want of feeling may arise from any of the patho-aisthenic causes already enumerated. Where the causes are organic, as in the destruction of the part itself; or of the corresponding portion of the brain; or from a division of the nerves of the part, no benefit can be expected from electricity, for it cannot restore the parts which have ceased to act. In cases where the want of feeling is simply functional (a state which is frequently found in young females about the age of puberty), the electricity may act as a stimulus, with the very best effect. It may also be employed in cases, where there is reason to believe that more or less injury has formerly occurred, but that the disease is remedied. The best form of apparatus is the electro-magnetic and magneto-electric machines; and the electricity should be used over the skin, the action of which we desire to excite, for a period varying from ten minutes to half an hour, and to such an extent that redness may be produced. In these cases, a sponge (fig. 31) may be conveniently employed for the application of the electricity.

NEURALGIA,

PAINFUL SENSATION.

(362). Neuralgia is somewhat the converse of the want of feeling, and may proceed from all the causes detailed in the paragraph on patho-aisthenics. However, causes existing at the dynamic pole, or muscle, are frequent sources of neuralgic pains; and as every sensor nerve is opposed to every dynamic nerve, neuralgic pains occasionally arise from some irritant, situated at a considerable distance from the spot exhibiting the

phenomena. In Pthisis, in a very incipient state, foreign matter exists in the lungs, which constantly causes neuralgic pains over the head, the side of the face, the back of the neck, shoulder, or over the skin of the chest. These are symptoms which I always enquire after, when I apprehend any tendency to that malady, and almost certainly find them to be present. All cases of Neuralgia are strictly patho-electric conditions; but electricity has not yet been brought to bear to any extent for their alleviation. Nervous power, however, is exhausted by the continuous voltaic current; and, therefore, I should consider that cases in which the cause of Neuralgia was local might possibly be relieved. In these instances, however, we have an infallible remedy in aconitine. Where this substance is useless, electricity perhaps would be of no benefit; and where aconitine can be employed, no surgeon would ever dream of subjecting the patient to the pain of a continuous voltaic current. In toothache, electricity both intermittent and continuous is said to be useful; and a special contrivance is sometimes employed (fig. 29) for its application.

DISEASES OF VISION.

(363). As Vision is essentially a voltaic phenomenon, diseased states do not differ from patho-aisthenics as I have already described them. Healthy vision may be prevented by the retina being veiled by some abnormal deposits, as in cataract. It may be interfered with by some altered state (congenital or acquired) of the refracting humours; and lastly, the electro-biological actions may be at fault. If too little or too much blood be supplied to the retina, or if its quality be altered, healthy vision cannot occur. If inflammation comes on, vision cannot be performed. Moreover, it is necessary to have a perfect integrity of the optic nerves to carry the sensation; and lastly, an integrity of the structures of the brain to receive them.

(364). Although all varieties in the action of vision, as partial or complete blindness, are patho-electric states in the strictest sense of the word, yet electricity should be very cautiously employed as a remedial agent. In certain instances, I have seen it of great benefit when applied to the eyebrows, skin of the forehead, eyelids, and neighbouring parts; and an instrument is sold for (fig. 28) applying it directly over the globe of the eye. The cases, however, in which it is applicable are few, because it would be useless in disorganisation of the retina, optic nerves, or brain. Nevertheless, in cases free from inflammation and disorganisation, when the surgeon desires a stimulus, it may be employed with the best of results. In certain hysterical conditions, and in certain cases of hemiopia, where the eye, from repose, seems, if I may use the term, to have forgotten how to act, its application is beneficial. Whenever electricity is employed to so delicate an organ as the eye, very feeble currents should be used. Electricity in the form of sparks from the electrical machine, or that derived from the electro-galvanic, or magneto-electric machines, may be employed. The one pole might be held in the patient's hand, whilst the other is passed over the regions intended to be stimulated.

DEAFNESS.

(365). Diseases of hearing are patho-electric states, like diseases of vision, and may arise from analogous causes. Where the malady depends upon any alterations of the structure of the organ itself, the connecting medium, or the brain, electro-therapeutic treatment must necessarily be abortive; but there are many instances where the vital actions only of hearing are at fault, as in cases of nervous deafness, and in which electricity may be applied with good effect. A contrivance is used to apply the electricity directly into the meatus (fig. 29); but perhaps it would be preferable to employ the electricity over the skin of

the face, and back of the neck, by passing one pole over those regions, and causing the patient to hold the other pole in his hand. The electro-magnetic, or magneto-electric machines are those commonly used for this purpose.

Preternatural acuteness of hearing is a very formidable symptom when it occurs in certain maladies. It is an electro-pathological state, but electricity cannot be used for its relief.

DISEASES OF SMELLING.

(366). Variations in the healthy powers of appreciating odours are electro-pathological states, and depend upon general patho-aisthenic causes before enumerated. I know of no instance in which electricity has been beneficially employed for their cure.

DISEASES OF TASTE.

(367). Taste is apt to be much impaired in derangements of the electro-biological circuit. An absence of taste, or an altered perception of taste, constantly occurs in fevers, or, in fact, in any malady having a powerful influence on the body. I remember to have seen cases where the application of extremely feeble currents might possibly have been useful; for instance, where patients have recovered from severe illness, and a total absence of taste has remained.

PATHO-DYNAMICS.

(368). In the human body, we appear to generate within our bodies but one physical force, namely, that which is produced through the medium of our muscles. For its manifestation, the muscular structure must remain intact, and a proper

amount of arterial blood must be supplied to that tissue. Moreover, the nervous communication with the central batteries must be properly maintained, an integrity of brain must exist, and lastly, the opposed pole of the peripheral battery must be in a condition to perform its functions. All diseased states of motion have their origin in these several regions; and, therefore, when we seek the cause of a patho-dynamic state, we must examine both poles of the peripheral and central batteries, the telegraphic communication between the two, and ascertain whether proper arterial blood is supplied to the entire circuit.

The diseases of motion are, first, those where motion is either increased, or where it takes place when not desired, as in tonic, clonic, and synclonic spasms. The remainder of the diseases of motion appertain to a diminished power, as alternating palsy.

TETANUS, AND OTHER TONIC SPASMS.

(369). Tetanus, or lock-jaw, exhibits itself as a violent tonic or sustained spasm. In this disease, the muscles of the anterior, of the posterior, and even sometimes of the lateral parts of the body, are thrown into the most violent spasm, causing the most agonising pain, and almost invariably ending in death. This fearful malady is a disease of motion, and therefore is essentially an electro-pathological state. It has its origin in all parts of the electro-pathological circuit, and is sometimes caused by changes in the central batteries, or brain; at other times, in the peripheral battery, or body.

(370). Mattucci has suggested the application of a constant voltaic current, for the purpose of exhausting the nervous power; but I must confess that I should myself rather rely upon general electro-therapeutic treatment, than upon the direct action of electricity itself: nor do I believe that the exhaustion of a powerful voltaic battery could possibly be applied to cure the patient. An electro-therapeutic treatment, by which we

alter the qualities of the blood, is perhaps much better adapted; and of all treatments, ether and chloroform, carried to as great an extent as the party could safely bear, and maintained over a long period, would give to the patient the best chance of success. The application of ether and chloroform would be strictly electro-therapeutic, inasmuch as the qualities of the blood would be altered, and thus the electro-biological circuit could not act in the terrible manner which it is observed to do in lock-jaw.

(371). In hydrophobia, a tonic spasm exists in the muscles of the throat and chest, which eventually kills the patient. Now we have learnt the use of ether and chloroform, perhaps they may be used to control the spasm, and save the patient's life. This malady is fortunately rare, and at present, I have neither seen nor heard of a case where it has been employed.

(372). Cramp is another instance of tonic spasm, affecting one or two muscles. It is a strictly patho-dynamic affection, and may arise from any causes acting upon any part of the electro-biological circuit, and sometimes manifests itself at great distances from the source of the mischief. Irritating or indigestible matters in the alimentary canal, frequently cause intense cramp in some of the muscular fibres of the leg, and occasion much pain and annoyance to the individual. I do not think that electricity would in all cases benefit this electro-pathological state.

COUGH, SNEEZING, HICCOUGH, ETC.

(373). Cough, sneezing, yawning, twitching, twinkling, are all varieties of clonic spasms, or irregular and sudden contraction of certain muscles. All these forms of spasm come from general patho-dynamic causes, but are chiefly referable to causes emanating in the peripheral battery. It is quite remarkable to what an extent these spasms may exist, without destroying life. Sometimes, after severe accidents, hiccough may

occur for days or weeks consecutively, and yet with careful treatment, the party may completely recover. I have not yet seen electricity employed usefully in any of these spasms, though this treatment must depend upon general electro-therapeutic principles.

ST. VITUS'S DANCE.

(374). Chorea, or St. Vitus's dance, consists of what are termed synclonic spasms, or multiplied agitation of the muscles. It is a strictly patho-dynamic affection, and appears rather to have its origin from causes emanating in the blood; for universal experience has shewn, that the administration of iron is of the utmost value, which fact probably depends upon electro-therapeutic principles. After the employment of iron, most surgeons agree upon the value of electricity. This, in my opinion, acts by breaking this spasmodic action; for it is very important that clonic and synclonic spasms should not become a habit in the system. The form of electricity which has been found by all operators to be most serviceable, is the interrupted current of the electro-magnetic and magneto-electric machine. One pole should be held in the hand, or placed at the side of the foot, whilst the other is passed over the skin of all the surrounding parts. The current should be continued from ten to thirty minutes every day, and should be as powerful as the parts can comfortably bear. Iron, quinine, and proper tonic diet, should not be omitted at the same time.

TREMBLING, FIDGETS, ETC.

(375). These states are also instances of synclonic spasms, and come from the general patho-dynamic causes already enumerated. Trembling frequently occurs from the effects of fear, which destroys the balance of action in the different parts of the body. It also arises from the action of mercury. After the

causes have been removed, electricity is of great value, as tending to break the habit, and to stimulate the parts to healthy action. In old people, the fidgets are a source of great discomfort, as they occur chiefly at night, and keep the patient perpetually awake and uneasy by the continual startings of the limbs. The malady generally arises from irritating matter in the stomach, and is best treated by tonics and attention to the alimentary canal.

ELECTRO-PATHO NOEMICS.

(376). Thus far, I have considered only the imperfections of the electro-biological circuit, which arise either from the aisthenic or dynamic pole of the peripheral battery: I shall now briefly consider the diseased states of the central batteries. In the first place, we have diseases of memory, which are manifested either in the impairment or the exaltation of this electro-vital phenomenon. Want of memory constantly occurs in epileptic cases; and in severe forms of the disease, I have seen persons who could not even remember their own name. At other times, bygone events are so firmly impressed, that they continually appear to the party; but perhaps in these cases, it is rather a strong impression than an absolute disease. Both these states are strictly electro-pathological.

IDIOTCY.

(377). Idiotcy may arise from an absence of memory, or from such imperfect organisation that the various mental phenomena cannot be evinced. It is certain, if the mental functions proceed from the organisation of the brain, that when the organisation is incomplete, the mental functions must be imperfect. Idiots frequently bear the impress of their character

in the form of the head; and a skull manifestly incompetent to contain the entire central batteries, indicates at once that the party must have a deficiency of mental power, and thus exhibit idiotcy. Sometimes, however, a perfectly-formed skull has been observed with an atrophied brain inside, in which case the individual was an idiot, without external signs.

GIDDINESS.

(378). Man only maintains the erect posture by an intricate combination of muscular movements. It continually happens, however, that the state of the central batteries is such, that the combination is not perfectly maintained. In this case, the patient feels the sensation which is termed giddiness, and may thus easily fall or be thrown down. I have lately seen a case where the central batteries were injured by excess of drink, and the party thus affected was blown down by the force of even a moderate wind. A want of supply of blood to the head, instantly produces giddiness, as will also exhaustion; and extreme cold is well known to produce this state. Giddiness is essentially an electro-pathological state, and must be treated according to electro-therapeutics. I cannot call to mind any circumstances in which electricity may be beneficially employed for its cure.

DELIRIUM.

(379). Delirium is another electro-pathological state of much importance, which has its origin, in many cases, from alteration of the qualities of the blood; in others, from exhaustion of the nervous system. Delirium is almost always seen in fevers, the patient usually becoming delirious at night; and in this case, delirium may exist for some time, without any permanent injury. Delirium tremens, or as the sailors emphatically call it "*The*

Horrors," may exhibit itself after severe nervous exhaustion, but more especially occurs in those who have lived freely. They shew, at first, a restlessness, which exhibits itself in their continually moving their hands, and which even amounts at times to a travelling propensity, and at last they sink exhausted either into sleep, or into the sleep of death. Some time since, I had to examine a patient who suddenly had a travelling fit, and who actually wandered from London, over two-thirds of the county of Kent, when at last he dropped down insensible by the road side, and was carried by some charitable individuals into a neighbouring house. Experience has shewn that, in these cases, it is necessary that the central battery should be replenished by sleep; and at present, narcotics and stimulants, separately or conjoined, are held by all good practitioners in the highest repute. There is an idea amongst many distinguished practitioners, that chloroform is likely to be beneficial in these cases; but I must confess, that for this malady, it appears to me to be a highly dangerous agent, especially for severe cases. Under these circumstances, I shall not myself employ it, unless supplied with positive evidence of its universal success. Although an electro-pathological state, delirium is not treated by electricity at the present time.

INSENSIBILITY.

(380). Whenever either a deficiency of arterial blood, or blood of vitiated quality is supplied to the sensorium, it is rendered unfit for its purpose, and the central batteries cannot act. For this reason, no impression can be received from without when a party is under the influence of carbonic acid, narcotic poisons, or any other materials which shall either alter the qualities of the blood, or prevent it from acting upon the brain. Insensibility may also arise whenever the organic structure of the central battery is deranged. Lastly, a party becomes in-

sensible when the connection between the central and peripheral batteries is destroyed. In all these instances, our treatment must be electro-therapeutic. We must, if possible, place the patient under circumstances favourable for the electro-biological circuit to act. If every requisite for action be present, then great benefit may be obtained by the stimulating properties of electricity. For this purpose, either the electro-magnetic or magneto-electric machines are constantly employed; and experience indicates that good results may be obtained by causing the electric force to act upon the muscles of the chest from the diaphragm to the spine. Electricity cannot remedy the crushed or divided spinal chord; and the instances in which it is serviceable, are only those in which the whole circuit is inactive, and requires a little stimulus to cause it again to act.

DESIRE FOR ACTION.

(381). I have already shewn that the faculty of desiring is a voltaic phenomenon, and is equivalent to tension in a voltaic battery. In some cases, we find that this desire is exceedingly depressed, the patient neither caring to move, nor to perform any function. In other instances, this desire is exalted; and I apprehend that a right consideration of this state is of the utmost importance in criminal cases. There can be no doubt, but that the desire to act often arises in young females from suppressed catamenia; and the question arises, how far they are responsible for that action. These cases open very important subjects; for if we hold the parties' irresponsibility, other parties so situated are taught that they may act with impunity; and, unquestionably, a strong moral impression might always, if present, control the faculty of desiring from doing wrong, be it ever so exalted. Where no strong moral impression exists in the higher batteries, to control each specific act, the party may be impelled to action in a manner repug-

nant to morality and laws. The state is strictly electro-pathological, and should be treated electro-therapeutically.

INSANITY.

(382). In a former part of this work, I have shewn that reasoning from the known to the unknown, upon general voltaic principles, we must admit that a variety of batteries exist in the brain, which constitute the mechanism of thought, and all other mental operations. In so complex a structure, it can be easily supposed that, from various causes, the mechanism should be often thrown out of action, which, in the operations of the mind, would be attended with extraordinary results. In the first place, we observe that the phreno-aisthenic battery, in which our knowledge is limited, is sometimes at fault. I have only recently had to examine a party, whose insanity consisted in the belief that a situation was open to him at the London Joint Stock Bank, with a salary of £300,000 per annum. Scarcely a month passes, without parties applying to the Bank of England for hundreds of millions, which they assert to be due to them. The phreno-aisthenic battery limits our knowledge; and sometimes a converse insanity to that just described exists, as when patients, having large property, fancy they are ruined, and the rich man believes he has not enough to supply his immediate wants.

(383). In the syndramic battery, we learn volume, concurrence, and relation, all of which properties are occasionally disturbed. Cases have been narrated, where a man could not be persuaded that he could go through a doorway, as his insanity caused him to believe that his volume was so great.

(384). I have lately myself had to report upon a curious case, where relation was disturbed, and the insane party thought that a gentleman was affecting the bodies of other individuals, causing a cancer in one, consumption in a second, and rheumatism in a third. Two of these parties actually died

of cancer and consumption; and the party supposed to affect them was in the same establishment. The insanity consisted in the relation of the action of this gentleman to the diseases manifested in the other individuals. Three or four years ago, the attention of the entire metropolis was occupied by an extraordinary trial of certain will-forgers, in which Fletcher, Barber, and others figured so notoriously. Shortly afterwards, I had to examine a gentleman who believed himself the object of a conspiracy, and that others intended to fix a similar forgery upon him. In this case, the circumstances of the trial were fresh in his memory, and he erred by thinking himself the object of suspicion. Here, probably, the syndramic battery was also at fault. Insanity arising from this battery, sometimes consists in the conjunction of two events happening at two different epochs, whereby they appear as one event, all the parts of which concur in the time of their occurrence.

(385). Insane persons sometimes err in their knowledge of the sense through which they are made acquainted with any fact; thus, they fancy they have seen a person of whom, in fact, they have only heard; and in the same manner the error occurs for other senses. These cases of error arise in the aisthenic-noemic and syndramic-noemic batteries.

(386). In the knowledge derived from various combinations of the central batteries, we obtain, sometimes, insane ideas. By combining a specific combination with infinity, and without at the same time limiting the combination, the insane person gives to it spiritual qualities. A gentleman, in the presence of a large number of others, fell down suddenly upon his knees before another party, and prayed that he would have mercy upon him. This second gentleman referred him at once to myself to enquire into so singular a phenomenon. On investigating the matter, it appeared that the insane man thought that the second gentleman was an angel come from heaven to punish him for his iniquities; and I found that the error consisted in the endowment of the specific man with the properties

of infinity, and not at the same time giving a limitation to him. From similar reasons, insane parties endow themselves with infinity, without limitation, and think themselves to be the Almighty. In the instances of this character which have fallen under my notice, there is manifestly more or less weakness in the central batteries, and I should feel inclined to place the source of the mischief in the phreno-aisthenic or limitation battery.

(387). Whenever there is a fixed insane thought, or thought occurring in the brain without external cause, the normal balance of the electro-biological circuit will be disturbed, and some action may ensue in consequence of the insane idea. A party fancying himself the owner of property wrongly withheld, may kill, or attempt to kill any person whose business it is to keep him from that which he thinks he ought to have. At the present time, there are two or three persons in confinement, for attempting to destroy gentlemen holding the highest official situations at the Bank of England, for not giving to the lunatics some few hundreds of millions, to which they insanely believe they are entitled.

(388). In all cases of insanity, electro-biology teaches that a sufficient control should be imposed upon the individual, to prevent any such attempt. But this control, and this confinement, should never exceed that absolutely required to prevent damage to himself, or to those around him. In the incipient stages of insanity, this control and continual watchfulness is most required, because we cannot tell to what extent the insane thought may extend. At a later stage of the malady, electro-biology clearly shews that a strong moral impression may control an insane thought; thus, a party will be kept from doing wrong by knowing that it will lead to present inconvenience to himself; or, in other words, that if the patient acted according to the manner in which his insanity led him, he would be punished.

(389). This class of unfortunates, notwithstanding all the

laws enacted in their favour, still require more attention from the legislature. Although insane, they are capable of as much enjoyment as other people, and ought to have every means of enjoyment allowed them. Unless there is a decided reason to apprehend that mischief may arise, they should have every liberty suitable to their unfortunate case. Imprisonment in madhouses, without sufficient occasion, is a very serious affair; and perhaps nothing but a specific examination of all the facts of every insane case periodically, will prevent relatives, or so-called friends, from occasionally making a traffic of the mental afflictions of rich lunatics. Insane thoughts alone should be controlled, and prevented from acting injuriously; and in all other respects they should be allowed to have every comfort, enjoyment, and pleasure which their means and their inclination can afford, and their medical treatment safely admit of.

(390). There can be no question, but that even half-mad individuals are a perfect pest to all their friends, causing them trouble and perpetual annoyance. Notwithstanding this inconvenience, the happiness of the insane individual should be considered, and no further restraint should be imposed, than what is requisite for the safety of the lives and property of themselves, or of the community. In madhouses, every mode of assuaging this heaviest affliction of humanity should be employed; and their happiness should be carefully studied on all occasions. No affliction is equal to that of insanity, and even the slightest trace of mental imbecility is distressing, such as that of repeating over and over and over again some trifling circumstance which the party has observed, but to which the mind is unable to give its proper importance.

(391). If we refer back to the structure which may be inferred to exist in the central batteries, we shall readily perceive that if the structure there developed be interfered with, the results observable in insanity must arise. The effects may arise two ways, either by an alteration in the arrangement, or

from the alteration of the qualities of the blood. It is notorious, that when the excretions of the liver and kidneys are not perfectly performed, the patient suffers what he terms the "Blue Devils," and other unpleasant thoughts. In these cases, the blood is at fault; it does not possess its normal properties, but gives rise to the same effects which a vitiated solution would in the ordinary voltaic battery.

(392). Before leaving the subject of patho-noemics, I must briefly allude to the subject of overwork, to which our great men are peculiarly liable. In former parts of this treatise, I have particularly pointed out, that for a healthy exercise of mental power, all parts of the central batteries should be used; and then, with proper sleep, a wonderful amount of work may be performed by the healthy man. When, however, the mind, day by day, week by week, month by month, and year by year, is directed to the same subject, the parts thus employed become exhausted, and a fearful state of depression is brought on. These cases are unfortunately too frequent, but should be remedied by absolute rest from the labours which have produced the mischief, and gentle employment in such other ways, and upon such other subjects as shall properly exercise the other portions of the central batteries. All monotonous labour, long continued, is very hurtful to the central batteries, and should be, as far as possible, avoided. Where the central batteries are injured, the peripheral also suffer; hence the person over-worked in mind suffers also in bodily strength.

(393). There are even other pathological states of the action of the brain, besides those already described, such as reverie, absence of mind, sleep-walking, and sleep-talking. In these instances, part of the brain is active, whilst other parts are passive. In some instances, these states amount to positive disease.

FITS.

(394). Having now considered the diseases which appertain to each respective part of the electro-biological circuit, we have

next to study pathological states, dependant upon the aberration of its acting as a whole. When action is impeded, an interval occurs, in which we cannot appreciate the influence of external forces; nor can we voluntarily originate any motions. This interval of consciousness we term a "Fit," which, literally in its truest sense, marks nothing more nor less than an interval.

EPILEPSY.

(395). Of fits, perhaps the most remarkable is that of Epilepsy. In this malady, the interval of consciousness is not complete, there being no sensation or voluntary motion of any kind. Conjoined with this interval, however, involuntary spasms of a tonic and clonic character of the most violent kinds frequently occur, during which the patient bites his tongue, and inflicts other damage upon himself. Epilepsy is strictly a disease of the actions of the electro-biological circuit, and has its causes either in the central or peripheral batteries; or perhaps even occasionally in the blood itself. Before the fit, in some cases, a peculiar sensation is felt in some part of the body; and in such instances, the fit may often be stopped by cutting off the supply of blood to that part. In other cases, the patient feels consciousness gradually leaving him. I have now a patient who, before the fit occurs, feels extreme pain in one hand; and I have found that by compressing the radial and ulmar arteries, the pain is stopped, and the fit for some time is warded off. The fit is an electro-pathological state; and we must therefore look to electro-therapeutic treatment to remedy the disease. In atonic states, iron is of singular value; and I have also found that in strumous habits cod-liver oil is, in certain instances, of great utility. Epilepsy may occur from the presence of irritating matter or worms in the alimentary canal, and then may be cured by getting rid of the peccant matter. When

Epilepsy is consequent upon organic alteration in the central batteries, no treatment is likely to be effectual. I do not think that electricity can often be beneficially employed for Epilepsy.

COMA.

(396). Comatose fits arise from the action of the central batteries being interfered with, and are seen in apoplexy, effusion of serum in the brain, or pressure upon that organ from the skull itself. In all comatose fits, the mischief is thought to reside in the central batteries, and depends either upon the parenchyna being injured; or upon blood, deficient in quantity, or of an improper character, being supplied to it. Coma is a strictly electro-pathological state, and where the fit has progressed to such a state that the party breathes badly, then electricity may be beneficially employed to stimulate the chest, otherwise it would in all probability be useless.

FAINTING FITS.

(397). In Fainting Fits, the electro-biological circuit cannot act for want of a proper supply of the exciting fluid, or bright arterial blood to the central and peripheral batteries. It is therefore an electro-pathological state, and must be treated upon general electro-therapeutic principles. In certain cases, we can only save the patient's life by the transfusion of blood from another individual. In some cases, I can conceive it possible, that electricity might be employed beneficially to rouse the patient, though I myself have never had occasion to employ it.

HYSTERIA.

(398). Hysteria is a very remarkable aberration of the electro-biological circuit; for in this malady, every action of the body may be either increased or decreased. Sometimes it exhibits itself as an impairment of sensation, the patient being unable to feel, see, taste, smell, or hear. At other times, these sensations are preternaturally exalted. Again, the dynamic pole of the peripheral battery is in like manner sometimes influenced, there being a loss of power; whilst, at others, that power is exalted. The central batteries are as much the subject of this disease as the peripheral; and extensive impairments of function, or excess of action, may be observed in different cases. In Hysteria, moreover, many of the functions of the body are influenced, such as those of the skin, kidneys, and the alimentary canal, shewing their obedience, in some degree, either primarily or secondarily, to the electro-biological circuit. The treatment of Hysteria must always depend upon electro-therapeutic principles. At one time, the disease may be controlled by moral impressions influencing the higher batteries; at other times, heat and cold can be advantageously employed; and, in the whole range of pathology, no disease requires more care for its diagnosis, or skill for its treatment, as the circumstances of each particular case differ; and the treatment must be entirely regulated by the circumstances. In certain instances, electricity might be used advantageously in hysterical affections.

COLLAPSE.

(399). When any violent impression is made on the electro-biological circuit, its action is depressed, and the patient is said to be in the state of collapse. This state is caused by a shock to the system, which may be either psychological, influencing

the entire system from its action on the higher batteries, and thus influencing the entire circuit; or physical, by an extensive injury to the body, such as by crushing, tearing, burning, or by the destruction of any large extent of the peripheral battery. Persons frequently instantly die under the influence of strong moral emotions, as those of joy or grief; from this cause, collapse is then an electro-pathological state produced by the excessive exhaustion of a powerful action on the electro-biological circuit; and the treatment must be directed to the renovation of the powers of the system. States of collapse, where the patient is hovering between life and death, are perfectly frightful. In these instances, the surgeon can only save his patient by incessant care, watchfulness, and exertion; and it is truly one of the delights which the medical profession is alone permitted to enjoy, to see the apparently dying man regain his exhausted power, and be restored to his family by care and attention. I have never used electricity for collapse, though it is possible that in some cases it might be advantageously employed.

INDIGESTION.

(400). It has been abundantly shewn by Wilson Phillips, and other experimenters, that digestion is influenced by nervous action. In fact, we all know that the process of digestion is instantly stopped by strong moral emotions, and does not take place freely when the electro-biological circuit is much exhausted or tired. A considerable amount of power is required for digestion itself; and when that power is depressed from any circumstance, digestion does not perfectly take place. Now, a question naturally arises upon this subject; for if indigestion is an electro-pathological phenomenon, dependent upon absence of electro-nervous power, we might infer that electricity might artificially supply the desideratum and get rid of the affection. Electro-Biology answers that, in all probability,

such would be the case, and that the artificial employment of electricity would compensate its natural want. It is a very important element in the matter, that the electricity should be employed in the same way that it naturally acts in the body; and I have no hesitation in stating, that although I have given the subject the most careful consideration, I am compelled to come to the conclusion, that I know no mode of applying electricity to supply the defect: that is to say, I do not think it possible to apply electricity in the same way that the nervous power acts.

(401). It is right, however, to state that some observers have believed that they have derived benefit by the use of electricity; and if any person is desirous to try it, I would recommend the intermittent current of the electro-magnetic and magneto-electric machines to be passed from the back of the neck, to the pit of the stomach, the operator keeping the poles moving over large tracts of cutaneous tissues. For myself, I have but little confidence in it.

AMENORRHŒA.

(402). In a former chapter, I have detailed the remarkable effect which electricity has upon the motion of the blood in the capillaries; and thus it is ascertained that it must influence all actions which immediately depend upon the circulation of the blood. In Amenorrhœa, we may assume that the uterus is not perfectly supplied with blood, to perform the normal functions; and in these cases, electricity comes to our aid with the best possible effect. Of course, if the female is in a state of bloodlessness, it would be in vain to expect her to give off blood, or blood-like materials. In consequence of this, the general powers of the patient must first be regarded; and the use of iron, in all its forms, has the sanction of the experience of every medical man, as an invaluable remedy in these cases.

(403). When, however, the practitioner thinks that the patient is competent to excrete the catamenial fluid, he may apply electricity with the best result. He should apply it to those parts where abnormal sensations are felt in disordered states. In these instances, the inside of the thigh, the loins, and the bottom of the stomach are the subject of uneasy sensations; and over these regions the operator should employ the poles of the electrical apparatus, and move them about, to cause a large extent of surface to be acted upon by the electrical power. Under this treatment it will frequently return. We occasionally perceive cases, in which the suppression of this function is attended with much constitutional disturbance, such as the continual recurrence of hysterical fits. In these cases, it is sometimes of importance to cause the secretion to take place with the least possible delay, when the electricity should be applied to the uterus itself, by introducing a Radford's conductor (fig. 27), or any similar contrivance, into the vagina, that it may actually come in contact with that organ. The opposite pole should be moved over the lower part of the stomach, the surface of the thighs, the loins, and surrounding parts. The amount of electricity must not exceed that which the patient can comfortably bear, which, in this instance, is but slight. The current from the electro-magnetic or magneto-electric machines, is best adapted for this purpose, and forms a very valuable adjunct to other remedial measures.

BARRENNESS.

(404). The same reasons for which electricity is rendered valuable in amenorrhœa, might lead us to expect that it would tend to rectify this state in the female; for, by causing it directly to act upon the uterus, it is calculated to increase the supply of blood, and thus remedy the defect.

UTERINE INERTIA.

(405). The uterus being a muscular structure, and electricity causing pre-eminently muscular contraction, it may be expected, that to cause uterine contraction, electricity would be the best stimulus. Cases have been published where it has been used for this purpose, though it should be borne in mind that electricity does not stimulate involuntary muscles to the extent to which it acts upon the voluntary muscles. Upon this matter, I cannot write from my own knowledge; and although I conceive the remedy to be worth an extensive trial, I am afraid that it will not be found so beneficial as at first sight appears.

(406). The observations which have been made on uterine inertia, apply also to uterine bleeding, which occurs from the mouths of the vessels not being sufficiently closed after parturition. A far greater number of observations are required to establish its benefit, than has at present been made. Dr. Radford has proposed its use for these purposes, and has contrived a director for its application (fig. 29).

ASTHMA.

(407). Asthma arises from such various causes, that it will be out of place in the present volume to consider it in detail. There are certain instances, however, in which benefit may be derived from the application of electricity to the chest. In this instance, the muscles of respiration should as far as possible be brought into play, and the electricity should be continued till the skin of the surface is reddened. I need hardly state that electricity will be valueless, if organic changes have been the cause of the asthma, as it is only calculated to be eminently useful in functional derangements. The electricity which is preferable, is that derived from the electro-magnetic and mag-

neto-electric machines. It should be used to as great an extent as the patient can comfortably bear.

ASPHYXIA.

(408). A person suffers from asphyxia whenever he is cut off from the oxygen contained in the atmospheric air, or when he breathes other gases, as those of hydrogen, carbonic acid, etc. In these cases, the blood becomes vitiated, and ceases to excite either the central or peripheral batteries. Asphyxia, or as my distinguished teacher, Dr. Watson, more properly called it, apnœa, is a strictly electro-pathological state. Now electricity alone cannot remedy such a condition, though, in certain instances, it may be most advantageously employed. When, for instance, a stimulus to the muscles of the chest is required, it may be advantageously employed; as, for instance, after poisoning by opium, drowning, and other similar cases. Electricity should, however, only be regarded as an adjuvant, and not at all comparable to the value of the action of oxygen upon the system. For this reason, electricity should never be employed to the exclusion of other remedies, though as an assistant, it deserves a prominent place. The value of electricity in these cases is extensively admitted by medical men.

ABNORMAL STATES OF SECRETION AND EXCRETION.

(409). It is still unknown to what extent secretion and excretion are influenced by the electro-biological circuit, and consequently the relation in a state of disease is equally obscure. The kidneys excrete more urine, and urine of a different character in certain states of nervous excitement; but this does not prove that its action is immediately dependant upon nervous influence, because, in this state of the system, the blood may be altered, and thus secondarily influence the kidneys. I have

heard of cases where electricity has been employed with the view of stimulating these organs, but I really do not pretend to know in what manner a current of electricity can be made to pass through them.

(410). The observations made upon the functions of the kidneys apply also to that of the liver, though I believe it is still less under the action of electricity evolved in the electro-biological circuit; and I know of no mode by which a current of electricity may be made effectually to act upon that organ. The alimentary canal is much more under the action of the electro-biological circuit than either the kidneys or liver. All abnormal states of the alimentary canal affect this circuit, and, conversely, all abnormal states of this circuit affect the alimentary canal. I have seen individuals on whom the application of electricity always acts as an aperient, though it is not commonly used for that purpose. In certain instances, where the intestinal canal is distended with gas, electricity would act as a fair stimulus.

(411). I have heard that electricity has been advantageously employed at the Free Hospital, to rally a patient in the collapsed stage of cholera, — a fact which I mention here, as this disease involves, to a great extent, the functions of the alimentary canal.

(412). The functions of the skin appear to be influenced by nervous action; a person in great fear will break out into a profuse perspiration. The older electricians believed that the ordinary electrical machines would cause a copious exhalation, but electricity is not now employed for that purpose.

(413). If we now take a review of the cases in which electricity is beneficial, we perceive that it is useful in two classes of cases; those in which the circulation of the blood through the capillaries is sought to be influenced, and those in which the nervous actions are sought to be acted upon. In every instance where electricity is employed, we have also in almost every case, other means which may be used to attain the same end. The value

of electricity, as compared with other remedies, must then depend simply upon the comparative facility with which the end is accomplished; and the question of its application resolves itself into a question of time, convenience, and perfection.

Before I terminate this chapter, I think that it will be highly interesting to my readers, to quote an account which has been given of the first shock which was received by any investigator, and the account certainly shews the astonishment which followed the sensation:—

"The end of the year 1745, and the beginning of 1746, were famous for the discovery of the accumulation of electricity on glass, called the *Leyden Phial*, so called, because the experiment was made by Mr. Cuneus, a native of Leyden; but the person who made the discovery was Mr. Von Kleest, dean of Cammin. On the 4th of November, 1745, the first shock was felt by this gentleman. He says, when a nail or piece of thick brass wire is put into an apothecary's small phial, and electrified, remarkable effects follow. Mr. Muschenbroek tried the experiment with a very thin glass bowl, and says, in a letter to Mr. Reaumur, that he felt himself struck in his arms, shoulder, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow and terror, and that he would not take a second shock for the kingdom of France. Various accounts are given of the effects of the shock; the most remarkable is that of Mr. Winckle of Leipsic. He says, that the first time he tried the Leyden experiment, he found great convulsions in his body from it, that it put his blood into such great agitation, that he was afraid of an ardent fever, and was obliged to use refrigerating medicines; he felt a heaviness in his head, as if a stone lay upon it; twice it gave him a bleeding at his nose. His wife had the courage to take two shocks, and found herself so weak that she could hardly walk. A week after, she received another shock, when she bled at the nose."

CONCLUSION.

Throughout this treatise, I have felt, in every department, my inability to do justice to the subject, which I have found to be far beyond my powers, either of physical capabilities to observe, or of mind to appreciate. Nevertheless, every step which I took, indicated more clearly that a work of this character, however imperfect, was required by investigators of science. In attempting to detail my experiments upon the subject, and in pretending to offer my own thoughts upon those experiments to the world, I felt that I should perhaps justly incur the censure of some individuals. My object, however, has been to endeavour to incite others who may have more leisure, greater capability, and higher mental endowments than myself, to follow this investigation.

In submitting this work to the Public, I may state that its development has afforded to me unmixed delight; and with respect to the opinion which other philosophers, after due deliberation, may be led to form of its contents, I can only say, in the words of the immortal Harvey, "*Spes mea in amore veritatis et dictorum animorum candore.*"

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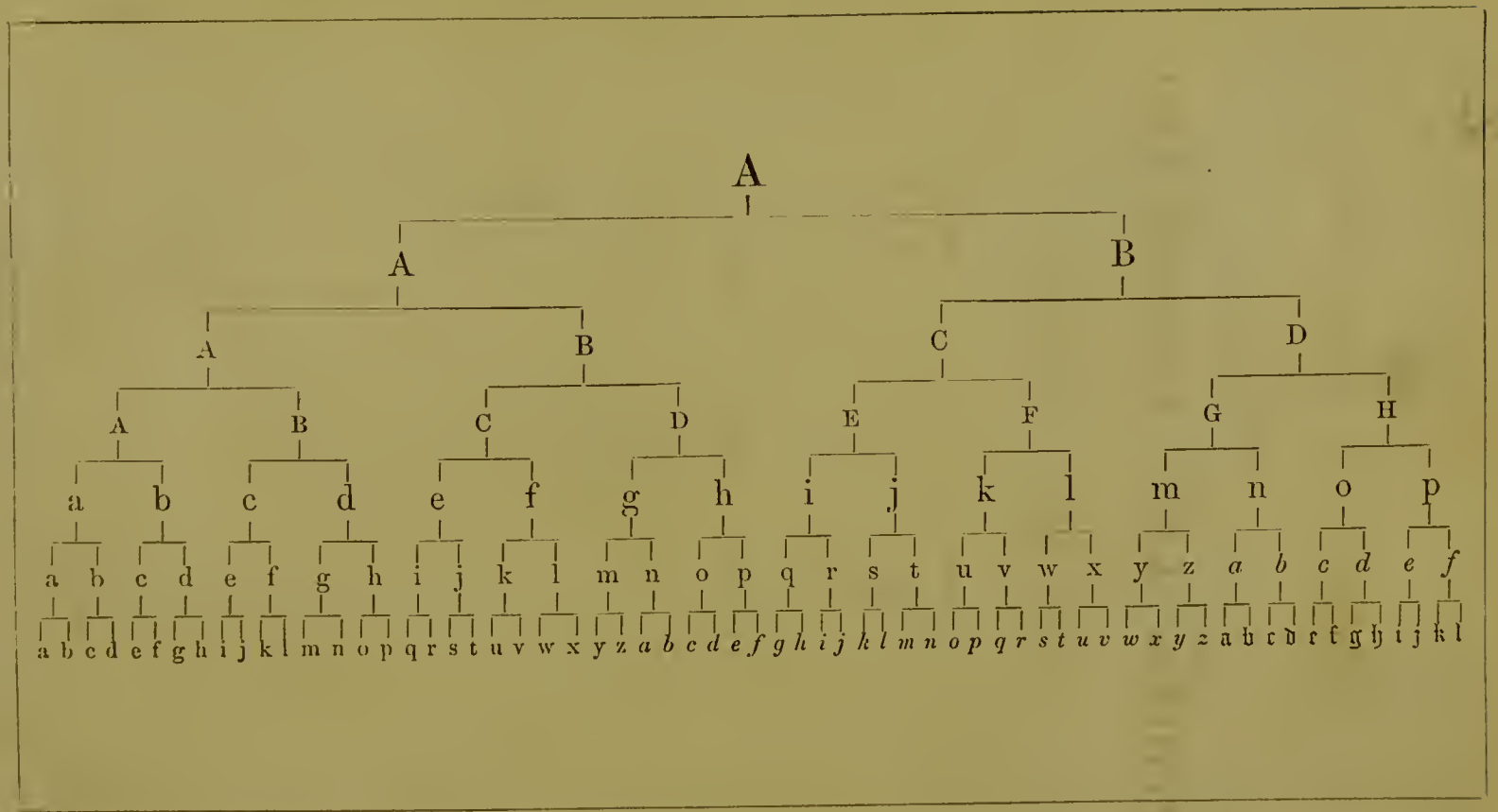

Geometrical Series of Cyphers, (*vide* Chap. II., *et seq.*)

THE PROCESS OF THOUGHT

ADAPTED TO

WORDS AND LANGUAGE.

TOGETHER WITH A DESCRIPTION OF

THE RELATIONAL AND DIFFERENTIAL MACHINES.

BY

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PREFACE.

This little volume constitutes a further contribution to the Electro-biological series of works which have now occupied my attention for a long period. They may be said to have been commenced many years back; and some part of the labour was even undertaken whilst still a student of medicine. On attending the Physiological Lectures of Professor Mayo, I was remarkably struck with the unsatisfactory account of the functions of the brain, and I was surprised that so little appeared to have been done in connecting mental operations with that organ to which they were due. I had not only the advantage of studying under this gentleman of genius, who is so well esteemed for his knowledge of the nervous system,

but I had also the good fortune to continue my studies under Professor Todd, who is also greatly distinguished for his acquaintance with this branch of Physiology.

From that period, I determined that I would endeavour to base some system of mental philosophy upon the functions and structure of the nervous system, and endeavour to compare it with the observed facts in mental science. In my earlier experiments, I found that a thorough knowledge of Galvanism, in addition to an acquaintance with other physical forces, was necessary. Although a pupil of the late Professor Daniell, yet, nevertheless, I found that in that science much had practically to be learned; and in acquiring that practical knowledge my Voltaic Battery was developed, and the materials for the Elements of Electro-Metallurgy worked out and adapted for the purposes of the arts. In seeking further information upon physical forces and their mutual relations, the work on the Sources of Physic was written.

Proceeding onward with my experiments and investigations upon the subject, it appeared to me

from the results which had been obtained, that the whole might be usefully classed together under the general term of Electro-Biology, which literally signifies, neither more nor less, than the relation of electricity to the vital functions. Upon making enquiries, it seemed to be a universal opinion amongst those qualified to judge, that a very small number of copies of the work would be sold, inasmuch as the public had great distaste for such investigations. Nevertheless, a large edition was printed, and certainly its rapid and extensive sale has been a matter of astonishment to myself, more especially as there is not only a French translation, but the substance of the work has been very faithfully given in *Chambers' Journal.* The facts and principles have also been so carefully rendered by the Newspapers and other cheap publications of large circulation, that there are very few educated persons who are not more or less acquainted with the subject.

Many friends, whose opinions I value, have suggested that the matter has been hardly sufficiently elucidated; but, in answer thereto, it is right to state, that my object has been to place

the entire system before the Public in so small a space that any inconsistency or incorrect deduction, in any part of the scheme, may be immediately seen, and dealt with at once. To remedy, however, the defect of the abstruseness of the work, and render the subject more attractive, the treatise on Instinct and Reason was written and illustrated with numerous engravings.

It has been mentioned to me, on several occasions, that I do not take any pains to persuade the public, and induce them to take up the system I have developed, and which confessedly requires intense study fully to grasp. To this, I reply, that in my opinion it is neither consistent with the interest, nor with the dignity, of science, in any way to endeavour to induce any person to adopt any system; but, having made known its existence, it should be left to the diligent inquirer, who should, in his closet, carefully examine every fact for himself, and hold fast to that opinion which his natural powers of mind lead him to adopt. No true lover of science can possibly wish that his own investigations should do more than exercise their proper influence upon the sum total of that knowledge

which the labours of the philosophers of all ages have developed. Science loses its character when it is used solely to gratify the personal vanity, or either to make a name, or to give a fortune to its follower.

Although the system of Electro-Biology has extended with a rapidity, both at home and abroad, which even an author's sanguine expectations could not have led him to anticipate; yet many difficulties are opposed to its yet more rapid progress. The misapprehensions of other writers upon the subject, cause them to publish statements at direct variation with my meaning; and after three works have been already published, each explanatory of the subject, the reader may judge my inexpressible astonishment, at reading, a short time since, that Mr. Smee had asserted, that "Life was Voltaism," followed by a long argument to prove the incorrectness of the assertion!

Misapprehensions may arise from my own ambiguity of expression, or the reader's insufficient attention, or from the imperfection of words and language to convey exact ideas; but I regret to state that one or two instances have occurred

where there has been reason to fear that my words have been wilfully misrepresented, and statements have been put forward directly at variance with that which has been explicitly stated. This course, fortunately however, is so directly contrary to the practice of the literary men of this country, as to require no further comment.

This volume is a deduction from the general system of Electro-biology; and being a practical application of the subject may possibly be immediately useful. In submitting it to the Public, I am not without hope that the process of thought here detailed, and the artificial system of reasoning here given, may be of service, more especially as I dare venture to assert, that under the Relational system, if rightly used, no form of sophistry or quibble can be successfully employed; and it has the merit of allowing any number of premises to be used.

With respect to the relational and differential machines, it may, perhaps, be useful here to repeat, that they are described solely with the view of illustrating the artificial mode of reasoning, by the

aid of cyphers, which has been based upon the study of the laws deducible from the natural process of thought.

From the nature of the subjects on which I have been engaged, my writings have been much noticed, and whilst they have been too frequently the subject of immoderate praise, they have also, occasionally, received unmeasured abuse. It is customary only to quoted the good side; but I have been often amused to observe that opposite quotations could be selected upon every definite opinion. From my experience, whenever anything is violently abused, it is contrary to some favourite crochet, or popular prejudice, for which the holders venture an expiring struggle before it is for ever lost. Although quiet and repose might dictate to an author to bend to the follies or prejudices of the day, yet, to my mind, an author should faithfully record the results which he has derived from his own reflection and reason, without regard to the possibility of receiving abuse, or the desire of obtaining praise. Under the influence of this opinion, I have never, in any way modified my views, or kept back facts, to suit the public taste; and ex-

perience shows me that that course alone is satisfactory to the author, secures in the long run the respect of the Public, and what is above all, commands the respect of the writer's own conscience.

The whole work must be regarded as but a brief outline of the subject. On this account, it has neither fallen within the scope of the work, nor has it been in accordance to my own inclination to compare this system with the systems of others previously published, and which have been employed to the best of my ability whilst writing it. The study of these subjects affords to the mind the highest pleasure; and although the development of this book has already been a pleasing employment to myself, yet if it should be found of corresponding utility, it will in future years be an additional source of gratification.

7, Finsbury Circus.
March 18*th*, 1851.

PROCESS OF THOUGHT,

ETC.

CHAPTER I.

ON THE NATURAL PROCESS OF THOUGHT.

(1) Art does not enhance the natural perfection of Man.—(2) Reception of Ideas.—(3) Limitation of Ideas.—(4) Changing Ideas.—(5) Memory.—(6, 7) Powers of Mind.

(1.) The perfection of the operation of the brain, by which man performs the noblest attributes of his nature, can no more be enhanced by a knowledge of its organization, than the working of a steam engine could be improved, if it could be made to know the mechanism by which it obtained its desired result. Nevertheless, it is practically found that a study of the laws of mental operations is advantageous, inasmuch as such knowledge inspires confidence to its possessor, enables him to check any result which he has obtained by the natural process of thought, and thus adds a confirmation to his opinion previously formed.

(2.) Electro-Biology teaches that man receives impressions from the external world through the medium of his organs of sensation, transmits those impressions to the brain, and there registers them in certain combinations in such a manner, as to render the sensorium one vast mechanism, in which everything which has been heard, or seen, or felt, or smelt, or touched, has produced an effect which modifies the action of any impression which may be subsequently received.

(3.) It would appear then, that every idea, or action on the brain, is ultimately resolvable into an action on a certain combination of nervous fibres, which is definite and determinable, and, regarding the sum total of the nervous fibres, is a positive result over a certain portion only, which has a distinct and clearly defined limit. Thus, if we take ten nervous fibrils, and call them A B C D E F G H I J, and suppose an action to have occurred on D E F, the combination excited to action, will give rise to an idea which would depend upon their positive excitement, and the positive character of the idea would be limited to that combination. Instead of using the letters D E F, I may illustrate the proposition by assuming the fore-finger to represent those letters, when it would be apparent, that if that finger was placed in hot water, the idea of that particular action of the hot water would be confined to the nerves supplying that part.

(4.) The operations of the mind would be very simple, if they could be reduced to ideas of so simple a character; but in a state of nature, various ideas are represented to the mind continually varying: thus—whilst I write, the gas-light and fire-light excite the nerves of my eye, the crackling of the burning embers excites the nerves of my ear, and I feel the pen which enables me to communicate my thoughts. These different ideas are represented over a varying length of time; and their relations to each other are the source of our notions of Time—of Motion—of Cause. To illustrate my position by symbols, we may have A B enduring for some time, and whilst continuing, C D may come into play and pass away for E F, and then in their turn to pass away for G H, when A B may finally pass away, and C D arise; and at last D E F G may alone remain. Thus we should have several distinct ideas represented successively to the mind.

(5.) Ideas once implanted, may appear again to the mind at some future period, either as they were at first received or conjoined with other ideas, when the effect is termed an act of memory or thought; and this is distinguished from a reality by its being unaccompanied by an action on the nerves of sensation.

(6.) The mind has the power of combining a number of ideas to form a general law, or of

lysing a general law into the specific instances from which it has been induced. Lastly, it may analyse any specific idea into the combination of nervous fibrils excited.

(7.) When any new impression is received, the mind can determine the accordance or discordance between it and former ideas, or can determine the similar relation which exists between previously received ideas.

Such are the few leading powers which the mind possesses to conduct its operations; and the laws of their action will be found to comprise every case of mental operation.

CHAPTER II.

ON WORDS AND LANGUAGE.

(8) Memory.—(9) Communication of Ideas.—(10) Words—(11) Substantives.—(12) Substitution of Cyphers.—(13—16) Nature of Substantives.—(17—19) Adjectives.—(20) Pronouns. (21) Articles.—(22, 23) Combined use of Noun, Adjective, and Article.—(24—26) Verbs.—(27—29) Substantive Verbs. —(30) Adverb.—(31) Prepositions.—(32) Conjunctions—(33) Resumé.

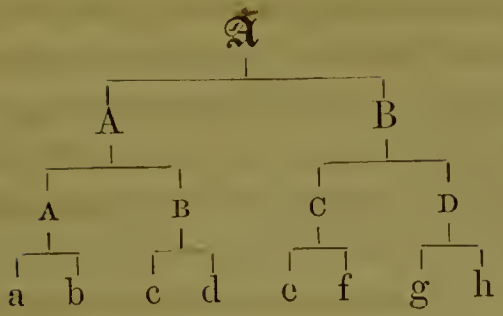
(8.) In the preceding chapter I have stated that external objects act upon the organs of sensation; that that action is transmitted to the sensorium; and that it is probably registered in a certain combination of nervous elements, to appear again on subsequent occasions, constituting an act of memory.

(9.) For the purpose of communicating these ideas from one person to another, or of recording them for the purpose of bringing the event again before the mind, we have recourse to various signs, sounds, or symbols, which represent various images impressed on the brain.

(10.) But from the amazing number of images which may be impressed upon the brain, the use of words becomes a complex phenomenon, because it would be impossible to assign a different word to every single image formed in the organization.

(11.) The first class of words which we employ comprises those which are termed substantives, and which, if carefully studied, will be found to include or embrace a large range of objects under one term; thus, when we speak of a man, we speak of an object which may give rise to a vast amount of images in the organization, as it comprehends white, red, and black men, good and bad men, men in health and sickness, etc.

(12.) In my last chapter I shewed that all mental images were made up of actions on a certain aggregation or combination of nervous fibres, each of which might be designated by a certain number, letter, or word. Thus we may use certain letters of the alphabet to designate certain combinations of nervous fibres. The letters indicating the combinations may be further arranged in a geometric series, as in the subjoined diagram, and it will be immediately observed, that in the first line we have one letter, in the second two, in the third four, in the fourth eight, all having relation to each other.



(13.) In assigning the substantive word to any action, we select a combination which is common to, or forms part of a great number of images, thus if a b c d form a combination which is always present when a man is represented to our senses, we may give to that combination the term *man*, or in symbolic language A, which will be found to include these letters.

(14.) It will thus be seen that generally a substantive is a part of speech given to the action on a combination of nervous elements, which are affected in common by a large class of objects, and is, therefore, in itself a very general term. The words *man*, *dog*, *ground*, *star*, may serve as an example of the noun or substantive. Grammatically a noun may be defined to be a word used for some action, real or imaginary, which has occurred in the brain. It is immaterial whether the images to which we have given the names of nouns are produced by actions through the organs of sensation, or whether

they are mere thoughts, and have no external existence, as a word of the nature of a noun may be given to any action of the sensorium.

(15.) A mere noun can convey little or no knowledge when used by itself; for instance, the word *man* used apart from any other word, either implied or understood, would, by itself, communicate no real knowledge from one person to another, as it would neither express who the man was, where he was, what he was doing, or, in fact, any other circumstance concerning him, or even whether the image to which it referred was used to signify a thought or a reality.

(16.) For the purpose of more accurately defining the noun, we add some word common to another combination of actions, or virtually we add a word, having some of the properties of a second noun, to it; but the second word so added, we term the adjective. Thus if we speak of a good man, we have defined the character of the man, or limited our observation to a man who is characterized by some quality of goodness. If A represents a man, B comprises the combinations of the actions of the brain, which we term goodness; then if we speak of A with some portion of B conjoined, we have restricted or limited our observation to the combinations of A, to which some of B are added.

(17.) It will be perceived that there is nothing peculiar or definite in either A or B, which should entitle it *per se* to the name of a noun or adjective, for either might be the noun, and either might be the adjective, and yet the effect would be very different. In the one case we should have *good man;* in the other, *manly goodness.* In these cases, the combination to which we desire to call attention is the noun, and must be accurately defined, and the word by which the extent of the noun is limited, is called the adjective.

(18.) When we use a word adjectively and couple it to a noun, the adjective implies that only a portion of the actions of the brain which led to the idea from whence the word is derived, are coupled with the noun; hence, as the amount varies, we have various degrees of the word used adjectively, as *good*, *better*, *best.* The information conveyed by an adjective, is not of that positive character which is conveyed by a substantive; and when I say a good man, I should express it by symbols, by using A for man and B—? for some unspecified amount of goodness. If I said or wished to express manly goodness, I should use B for *goodness* and A—? for *manly.*

(19.) It follows from the above remarks, that the adjective is a far less perfect part of speech, and is unable to be used for the communication of those

absolute ideas, which may be communicated by the use of the noun.

(20.) There are other classes of words which require but little comment; thus we employ pronouns to prevent the repetition of nouns. These words have no meaning in themselves, unless some noun, either expressed or implied, has preceded their use, and both grammatically and biologically they must be referred to the class of nouns.

(21.) Various questions have been raised as to the use and signification of the articles *a* and *the*. It appears to me that, biologically considered, *a* is employed to signify any one or some unknown one. The word *the* seems to have the power of limitation to some particular one or some particular class. In accurate symbolic language wherever *the* is employed, it is necessary that the additional description should be applied to the noun, to mark the individual or class to which the word *the* limits the application of the word.

(22.) By the combined use of the noun-adjective and article, we are thus enabled to give a more or less correct picture of any real or imaginary object to a second party; but it appears most especially necessary that these words should be used in the same sense by both parties, otherwise no true information is communicated.

(23.) The mere use of the noun, however, gives us by itself no real information, because a second person would require to be informed whether any word represented a mere thought or image of the imagination, or a reality; in fact whether it referred to an object which existed in all its integrity in the external world, and which produced the action upon the organs of sensation. A noun might also signify a mere abstraction of various actions.

(24). The words used to express this important part of the idea, are termed verbs. But a verb does more than this, it signifies the relation of the thought or reality to other thoughts or realities. In fact, it marks the time of the occurrence of the thought or of the reality. Electro-biologically, we may define a verb to be a word used to signify the changes, on the sensorium of the respective portions of one image, and their relation to those of other images.

(25.) To explain this definition, it is important to remember that the brain is one large organ, on which a series of impressions are being continually made, both from the action of external agents upon the organs of sensation, as well as from the changes going on within our own frame. If a thought or reality occurs at the moment at which we are actually receiving the second impression, then we speak of the time present, and we say *It is*. Suppose

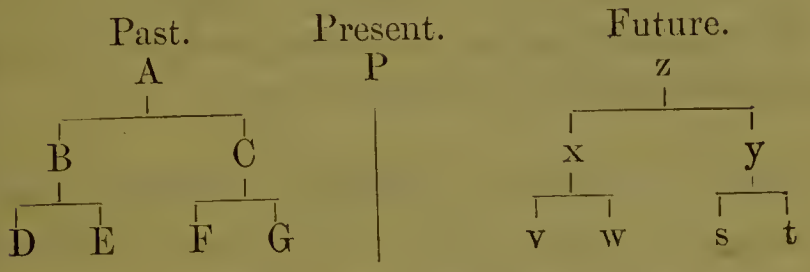
A B C D to represent primitive nervous fibrils, and w x y z to represent other nervous fibrils, if the actions on B C and x y coincided at the moment when x y was being excited, we should state that the idea derived from B C, existed at the present time, or in the language of the verb *is* or *exists*. Now if we examine the changes which are continually occurring in the mental images, we may express them in two series in the following manner:

1st.	A B	A B	A B	B C	C D	A B	
2nd.	l m	m n	n o	o p	q r	s t	

In the above diagram we perceive that the two series of changes take place unequally. It is from this double series of ideas that we derive our notions of time, for those combinations which change least frequently, are said to occupy the longest time. For practical purposes, we select one series of changes as those of a clock, or the changes produced by the revolution of the earth as a standard, and refer all other changes to those.

(26.) Practically, when we use verbs, we do not set out accurately the changes which actually take place, but we employ words to signify time present, time past, or time to come. All verbs may be conveniently arranged into two geometric series, the one signifying time past, the second, time to come, the two being divided by a line, denoting

time present; or we may unite the three together into one series signifying all time.



(27.) But most verbs shew more than the time of the occurrence of any idea; or rather the relation of any one idea to any second idea; for if examined, they will be found to communicate some knowledge similar to that imparted by the noun; and hence these verbs might be called substantive-verbs. If I say that John sits, it not only indicates John, and his existence at the present moment, but it goes further, it shews his posture. In like manner if I say, I think it not only indicates time present, but it shews that the idea is an action of the brain, which has not necessary external existence.

(28.) Substantive-verbs communicate even a far greater range of ideas; thus if I say that John came from Brighton, the words *came from*, would not only represent that John was at Brighton and is now here, but they infer all those changes which occurred during the act of coming here. Whether we regard the motion of the carriages, the change of the view, the number of ticks of a watch, the

pulsations of the heart, the occurrence of thoughts during the journey, the changes would be almost infinite in number. All these changes it would be too long and tedious to recount, and yet they are are all included in the word *came*.

(29.) A verb has essentially a reference to some change, for without it the verbs cannot be used; and even when we mark the present time, that present has relation to the past and future.

(30.) The adverb is another part of speech, which still further gives exactness to our descriptions, by limiting the scope of any observations. It is frequently used merely to assign the value or extent to an adjective or verb, as in the case of *nearly*, *chiefly*, *exceedingly*, *very*. Other adverbs perform the same functions to the verb as the adjective does to the noun; as in the words *prudently*, *softly*, when in these cases they limit the extent of the meaning of the verb, by adding to it a certain amount of the properties of prudence, softness, etc.

(31.) Prepositions are used to shew the mutual relation or position of separate ideas; as in the words *above*, *below*, *behind*. In these cases they shew the manner in which the image is received by the senses. Electro-biologically, they help in many cases to signify the particular combination which is represented to the mind; thus a man placed

upon a horse, would be represented by a different combination of nervous elements to that which would be produced by that of a man below, or behind, or before a horse. A very different idea is signified when we say that a man came from Brighton to London, from that which is communicated when we say, that a man came from London to Brighton.

(32.) Conjunctions are employed either to compress two ideas into one, or to separate one portion from a more extensive idea. In the first case, the conjunction is called copulative; in the second, disjunctive; conjunctions are, in fact, equivalent to the signs of *plus* and *minus*.

(33.) Such is a brief *resumé* of the mode of communicating impressions made on the sensorium, from one person to another. In the first place, we use a noun, which is a sort of generic term given to certain combinations common to many ideas. This general idea is then limited by the adjective, and still further by the adverb. The verb is then employed to signify the time of the occurrence of the idea, or of the changes which took place with it; and these changes are more particularised by the use of other adverbs. We, however, introduce other nouns; and their relations are more accurately detailed by prepositions and conjunctions. It is manifest that the whole system is artificial, and whilst we must

deplore its insufficiency to communicate exact ideas, yet we must, at the same time, marvel at the great and glorious results which it has been the means of effecting.

CHAPTER III.

RESOLUTION OF A SENTENCE.

(34) Resolution of a Sentence.—(35, 36) Arrangement of Nouns. —(37) Notation of Naturalists and Chemists.—(38—41) Limited Nouns.—(42) Geometric Arrangement.—(43) Arrangement of the Verb.—(44) Qualified Verbs.—(45) Relation of Verbs to Substantives.—(46) Conjunctions.—(47) Notation of Sentences.—(48) Example.—(49) Value of the Notation.—(50) Resumé.—(51) Application.

(34.) From the observations which I have already made, we are now in a condition to resolve a sentence, or so to set it out, that it may appear on paper as it would have acted on the brain, had it been a reality instead of a mere description; and this resolution would not be difficult were the idea confined to the same instant of time, but a variation of time involves a succession of ideas, which it is difficult to express.

(35.) In the first place, we must arrange the substantives in their natural relations, and we must put those substantives which contain the smallest number of known combinations at the top, then we

may place successively lower all those which contain a less number of combinations. When, however, we have two substantives agreeing in all combinations but the terminal, these two should be placed on the same line. Upon this plan we should arrange the substantives, Animals, Brutes, Man, Reds, Whites, in the following manner:

Animals A

Brutes B Man C

D E Reds F Whites G

In this case we have three degrees of perfection in the specification of these words. Animals may be said to consist of A, Man of A C, Whites of A C G. Now the word Brute in this arrangement, has the same amount of definition as that of Man, and may be expressed by A B; and Reds express the same definition as Whites, and may be represented by A C F.

(36.) In this case I have only assumed one letter for the specific qualities of each noun; but if the signification of any word can possibly be disputed, then instead of one letter we must use a series of letters expressive of the qualities in such a way, that there can be no dispute upon the exact limit of the word, for until any two disputants agree precisely upon the signification of the word, any superstructure based upon it may be rendered of no effect.

When the meaning of any word is under dispute, it must be unravelled by other words, till the disputants have the same ideas for the same words.

(37.) Naturalists use, in some respects, a similar mode of describing different animals; as when they divide them into individuals, species, genera, orders, classes, etc.; and chemists more accurately note the composition of substances by symbols in an analogous manner.

(38.) When arranging substantives into their relative position, we should bear in mind any word which is appended to them to limit their signification, such as the adjective; for instance, if I speak of "a man," "a white man," "a happy white man," I have three different degrees of limitation in the three different cases.

(39.) So also with regard to the adverb joined to the adjective, the meaning is more particularised, as "a very happy white man" bears a different amount of limitation to that expressed by "a happy white man."

(40.) As, moreover, prepositions have so far an effect upon the meaning of the noun, as to limit, or particularise its signification, we must also add their value to the noun in any formal resolution of a sentence, as different significations would be

expressed by "to London," "into London," "upon London," "above London," "below London," "around London," "about London."

(41.) When two nouns are joined together by a conjunction, they collectively form one idea, as "John and Thomas." Sometimes the idea is limited by their use, as "all but Thomas," where the meaning is lessened by the conjunction. In this way the copulative conjunction is equivalent to the sign *plus*, and the disjunctive to the sign *minus*.

(42.) Perhaps, upon the whole, nouns having certain properties in common, had better be divided into the geometric series, 2, 4, 8, 16; and thus every term might be distinguished from every other term. By this arrangement, every word would signify the half of a word above it, and would conjoin the meanings of two words below it. This division appears to me well deserving the attention of naturalists, chemists, and other writers requiring the use of a large number of words. In application, partial difficulties would frequently arise, because practically odd numbers would interfere, but nevertheless, by a little management, such a division might doubtless be usefully effected.

(43.) Having considered the best mode of arranging the nouns, we are naturally led to consider

their mutual relations, together with the effect of the verb upon them. Verbs appear to signify a more complete set of actions than the noun, and in my "Instinct and Reason," I have shown that animals do not appear to have the power of appreciating their use. Some verbs simply show existence of an idea, as a thought, or a reality, at the time present. This hardly requires a sign for its designation; for it might be understood, that when we say, "John, here," that he *is* here. But any idea, be it a thought, or be it a reality not now existing, must have either existed at some former period, or may exist at any future time; and the time either present, past or future, may be represented with accuracy in a series as before described.

(44.) But the verb, besides describing the time at which the event occurred, expresses some substantive idea, then this addition must be appended to the noun to which it refers, as "John runs;" the word *runs* gives two ideas, one that John is in the act of running or performing the motion of running; the second, that this action is now taking place.

(45.) In many cases, verbs have relation to two substantives, as "John killed Thomas." In this expression, we understand that at some time past, the act of killing was done by John on Thomas, the first individual performed certain actions which caused a second set of actions to supervene on

Thomas. The verb here modifies the ideas which we derive of both nouns; and the sentence gives us the idea of at least three different states.

First,—John and Thomas both alive.

Second,—John in action—Thomas being acted upon.

Thirdly,—John alive—Thomas dead.

These series of changes or sequences, stand in relation as Cause to Effect, and in language may be rendered, that John caused the death of Thomas.

If we regard the origin of our ideas of Cause and Effect, we find that the idea of Cause is deduced from a change of matter acting upon other matter: the first change is called the Cause; the second, the Effect. Thus when we say that the fire causes the water to boil, we mean that the coal is changing into carbonic acid, which change acts upon the water and turns it to steam; the first change being the Cause; the second, the Effect. They may thus be regarded as primary and secondary changes.

(46.) The limitation of the verb by the adverb, may be treated as we limit the signification of the noun by the adjective; so, also, parts of a sentence coupled together or dissevered by conjunctions, may be treated as when used with nouns.

(47.) We are now in a condition to express any definite sentence by a series of letters, and give to it a definite form for the purpose of disputation or

study. It is absolutely necessary to set out the meaning of each word, so that its signification may be accurately defined; and hence, in some cases, it may be requisite to express a word by the combination of ideas which constitutes that word; thus if we use the word John, it may be necessary in some cases to show that John is of a certain family, and that he is a citizen, a Londoner, a white, a European, a man, an animal, an organized being.

(48.) In the resolution of a sentence we first set down the designation of the thing or person that first undergoes a change. This becomes a cause. The causality may be expressed by other letters, and designated according as we are enabled to communicate the manner of the cause. We next note the noun which is effected, and the value of the effect produced; and, finally, we designate the time at which the whole series of changes occurred.

(49.) As an example of this mode of notation, we may set down, "John and Thomas killed William." Let J stand for John, T for Thomas, C for causality, D for death, E for effect, W for William, P for the past; which electro-biologically would point to different distinct ideas having mutual relations, thus:—

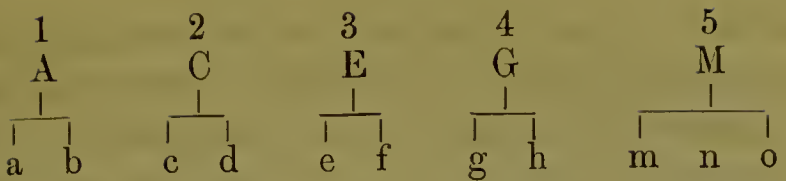
$$\overline{\overline{J\ T\ C}}\quad\overline{\overline{W\ E\ D}}\quad P$$

In the first place, John and Thomas underwent

certain changes, in consequence of which, in the second place, William underwent certain changes to death, the whole happening at some time past.

(50.) This mode of notation may, at first sight, appear more complicated than ordinary language; but if carefully studied, it will be found to afford us an artificial mode of reasoning, which, although immensely inferior to that which is in actual operation by the elaborate machine furnished us by nature, yet as far as it goes, may be conducted by fixed and immutable laws.

(51.) In reality the various changes indicated by the verb occur at different times. In any process of thought arising therefrom, the whole appears to the mind at one time. This constitutes a great difficulty in the notation of a sentence by cyphers, and can only be effected by several series of geometrical arrangements. One would be required for the description of the object changing, another for the description of the nature of the change, a third for noting the object effected, a fourth for the nature of the effect, and, lastly, we should require one series to denote the time of the whole series. This last had better be divided into three parts instead of two, to signify the past, the present, and the future; though after the first division the ratio of two may be maintained.



(52.) By the modifications of this system of notation, it is not impossible that acts of Parliament, deeds, and other exact documents may eventually be drawn; for if once the entire words of the English language were arranged in their mutual relations, this mode of writing would probably be the most exact form of language which could be adopted.

CHAPTER IV.

ON INDUCTION.

(53) Induction.—(54) Nature of.—(55) Illustration.—(56) Arrangement.—(57) Classes of Induction.—(58) Absolute Inductions.—(59) Induction of Probabilities.—(60) Possible Inductions.—(61) Induction of Means.—(62) Induction of Limits.—(63) Hypothetical Induction.

(53.) I have now to treat of the method by which the mind classifies a series of facts, so as to represent them by the shortest possible method. It is a faculty of great importance to man, inasmuch as by it he is enabled to communicate a large number of facts in a few words.

(54.) The process of induction consists in finding a definite and constant connection between two or more parts of any images, or sequences of images. When, for instance, we find that every individual person dies, whether male or female, we learn a number of individual facts, or rather, we ascertain that a number of human beings have ceased to live, and taken on the various changes of death.

We then ascertain that that which we call Humanity is common to all the cases, as one part of the fact; and that that which we call Death, is common; and this constitutes the second part of the fact: hence is induced that man is mortal, or in other words, that humanity and death are invariably conjoined at one time or other.

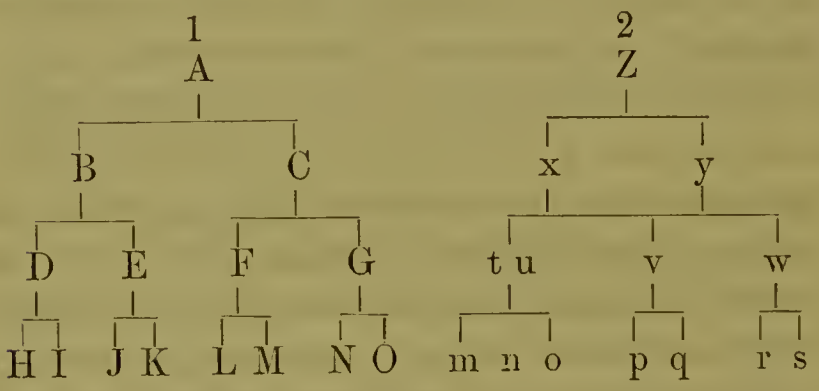
(55.) To illustrate the nature of induction, we may take a number of combinations of nervous elements, and call them by letters. If the combination A represents that part of an idea which is possessed by all men, and W the combination given by a sense of feeling, then, if we find that where A is present W is present, we have acquired a most important information; for if A is present ten thousand times, there will W exist. If B represents that which is common to man, and we find it always conjoined with X, denoting rationality, then we know that all men are rational; so if C represents that which is common to whites, and Y denotes happiness, and D represents the peculiarities of Englishmen, and Z the characteristics of freedom, then by this series of inductions we have acquired most important knowledge.

D C B A W X Y Z

But we observe, that man partakes of the properties of A B, therefore, he is W X, or is possessed

of feeling and rationality. Whites possess the characteristic of A B C, and, therefore, manifest W X Y, that is to say, they feel, are rational and happy. Lastly, Englishmen being designated by A B C D, manifest the properties of W X Y Z, or evince feeling, rationality, happiness and freedom.

(56.) The above statements may be also arranged as two geometric series, which for many causes are more convenient for study.



By this arrangement in the first series, A would stand for animal, B for man, D for whites, H for English. In the second series, it is manifest that feeling, rationality, happiness and freedom do not possess any immediate relation to each other, and therefore in the absence of any definite knowledge upon this matter, they may be arbitrarily assigned the symbols of m, n, p, r in the fourth row.

(57.) It may be useful to consider a few speci-

mens of inductions arranged in different classes, that we may the more properly estimate their value to man. For this purpose, we may consider them under six heads:—Absolute Inductions, Probable Inductions, Possible Inductions, Inductions of Means, Inductions of Limits, Hypothetical Inductions.

(58.) Of absolute inductions we find good illustrations in the properties of numbers: thus, if one be added to one, it makes two ; if two be multiplied by two it makes four. These instances are so familiar, that we are apt to forget that they are inductions ; but, if I state that the square of any number is equal to the sum of as many consecutive odd numbers beginning with units, as there are units in that number, as thus, $6 \times 6 = 1 + 3 + 5 + 7 + 9 + 11$, there probably will be but few of my readers who would be aware of the fact, and would only believe it after they had satisfied themselves upon the matter. Other examples of absolute inductions may be observed in our knowledge of the properties of geometric figures.

(59.) The next class of inductions which we have to consider, may be termed Inductions of Probabilities, because we induce a law of probability from a certain number of facts. This induction will not express to us the absolute fact in any one particular case. As an example of a probable

induction, we may instance that of the sex of children, which for our present purposes we may assume to be half male and half female according to observed experience. In reality the number of each sex is always equal. From this induction our knowledge is so far incomplete, that we cannot tell, when a child is about to be born, whether it will be male or female ; though we can calculate with tolerable certainty that out of a thousand children, five hundred will be males, five hundred females ; but we cannot tell from this knowledge which five hundred will be males and which females.

(60.) Of possible inductions, we may take in illustration the following assumed fact: amongst a thousand children one is born with six fingers, and we have no information as to the precise one which is the subject of the monstrosity. It is manifest that with this knowledge, it is possible that any one may be the subject of the disease.

(61.) The Inductions of Means is another kind of knowledge of considerable utility. This species of induction consists in ascertaining the sum of the values of a certain number of objects, when by dividing it by that number, we obtain the mean value. If we discover that four men weigh four hundred weight, then we know the mean weight of each of the four men, though we do not know in any one case the absolute weight.

(62.) The Induction of Means is much increased in value when we have the limits of variation between the different individual instances, thus a mean of 4 may be obtained between the limits of 7 and 1, 6 and 2, or 5 and 3.

(63.) There is yet one other mode of induction, which investigators frequently employ with advantage. Having a single fact carefully examined, they assume a law from it, and they examine other facts to see how far they agree or disagree with that law. This is called a Hypothetical Induction. This form of induction is most valuable if the investigator never forgets that it is a mere Hypothesis; but on the contrary, if he bends his other facts to suit the Hypothesis, then this form of induction is in the highest degree dangerous.

CHAPTER V.

ON DEDUCTION.

(64) Deduction.—(65) Perfect Deduction.—(66, 67) Imperfect Deduction.

(64.) As by the process of induction we are enabled to classify a large number of facts under one general rule; so by deduction we are enabled to apply this induced knowledge to any particular instance. As an example of a deduction, we may take, as an illustration, the deduction: "Man is mortal," or in electro-biological language, man A always suffers death Z. From this induction we rightly deduce that John A + B is liable to death, because John, contains A the properties of a man in his organization, or we may express the fact by symbols, that A + B is conjoined with Z.

(65.) Deductions are of two kinds, perfect and imperfect. In all cases of perfect deductions, the inference derived from the law is certain; thus, if I have twenty pounds, and add thereto twenty pounds, I may of certainty deduce that I shall then

have forty pounds, because I have previously learnt by induction that twenty and twenty make forty.

(66.) Imperfect deductions may be divided into several departments, for every deduction is imperfect in which the law which is sought to be applied is not absolute. From this cause it follows, that a deduction from a probable induction, or hypothetical induction, or an induction of means and limits when applied to any particular instance, is necessarily incomplete and unsatisfactory.

(67.) As an example of an imperfect deduction, I will assume as a law, that amongst great masses of children, half are boys half are girls. From this law it follows deductively, that of one thousand children we should probably have five hundred of each sex, but it by no means follows that out of ten children we should have five of each, for it might happen that the boys and girls are grouped together in masses of each, and, therefore, the law would not apply to very small numbers.

CHAPTER VI.

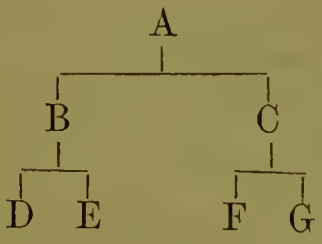
ON THE LAWS OF THOUGHT.

(68) Laws of Thought.—(69) Properties of Symbols.—(70) Laws of Symbols.—(71) Laws of Judgment.—(72) Reason.

(68.) In former chapters I have shown how every word may be expressed by a cypher ; and I have pointed out the manner in which we can express all ideas by this mode of notation. These symbols when rightly arranged as a geometric series, have certain properties to which the laws of thought are obedient, and are most important to be studied and thoroughly understood, and it will be now my business to endeavour to explain them.

(69.) Each symbol expresses something in nature which does not stand alone, but has certain relations to other symbols. If we arrange these symbols as a geometrical series, each letter would comprise the properties of a part of a symbol above it, and those of two symbols below it, and differ in some condition from those beside it : thus let A

represent animals, B brutes, C man, D blacks, E whites.



In this case A possesses properties common to the whole symbols ; B properties common to D E.

These symbols geometrically arranged, may be called higher, lower and equal ; the higher comprise those in which the characteristics are more general, the lower those in which they are more specific, and the equal those of similar exactness of definition.

(70.) The laws of these relations constitute the entire laws of thought, and all which possibly can be learnt by the reasoning powers from any given facts.

1. Symbols denoting ideas, are limited in number, although that limitation is so enormous that no man will ever be cognizant of them all.
2. Each symbol denotes a positive action of the brain
3. A mere negation only expresses that an action on a symbol is absent.
4. A positive symbol with a negative attached, limits the signification of the positive symbol.

5. Every symbol has something in common with every other symbol.
6. Higher symbols confer their entire power upon all their lower symbols.
7. Lower symbols confer some power upon all their higher symbols.
8. Equal symbols do not affect each other.
9. A combination of symbols possesses the combined powers of each separately.
10. A symbol partially affects some of the higher symbols of its equals.
11. A symbol does not affect the lower symbols of its equals.

(71.) The act of thinking consists in comparing the relations of symbols, and that of judgment in determining whether the two sets of symbols agree or disagree. By judgment we determine Affirmation, Negation, Probability and Possibility.

1. Affirmation consists in the absolute agreement between two sets of symbols; thus, A B and A B are alike.
2. Negation, on the contrary, consists in a non-agreement between two sets of symbols; as A is not A B, A B C is not A B, C is not A B. Cases of negation resolve themselves into three classes, — first, into that which comprises those cases in which the two sets of symbols agree, as far as they go, the second

set being deficient in amount; secondly, into that in which the symbols agree up to a certain point, but the second has something added; and, lastly, into that in which there is an entire nonagreement between the symbols.

3. Probability consists in the concurrence of all the known symbols in one set of symbols with those of a second set.

   Thus A B C plus, some unknown, is probably A B C D.

   The degree of probability in different cases is inferred from the extent of the concurrence; or rather we may say, from the proportion of the amount of the unknown parts.

4. Possibility consists in the absence of any positive discordance between the unknown symbols of two sets.

   Thus X Y plus some unknown may be possibly A B with some unknown, because both sets may consist of A B X Y.

5. An answer is absolute when the two sets compared consist of known symbols.

6. An answer is only probable or possible if a probable or possible symbol enter into either of the two sets compared.

7. An answer is only to the average, if either set of symbols contains an average statement.

(72.) I have now shortly detailed the laws of thought adapted to words and language, and

simplified by the use of symbols. For the purpose of studying these laws, the student is referred to the geometric series of symbols appended to this work; and he will readily perceive their importance and truth. In all disputes and discussions, having once referred the words employed to their proper relation in the series, the legitimate deductions can be immediately learned, and thus a far greater certainty may be given to our mode of reasoning.

CHAPTER VII.

ON THE RELATIONAL AND DIFFERENTIAL MACHINES.

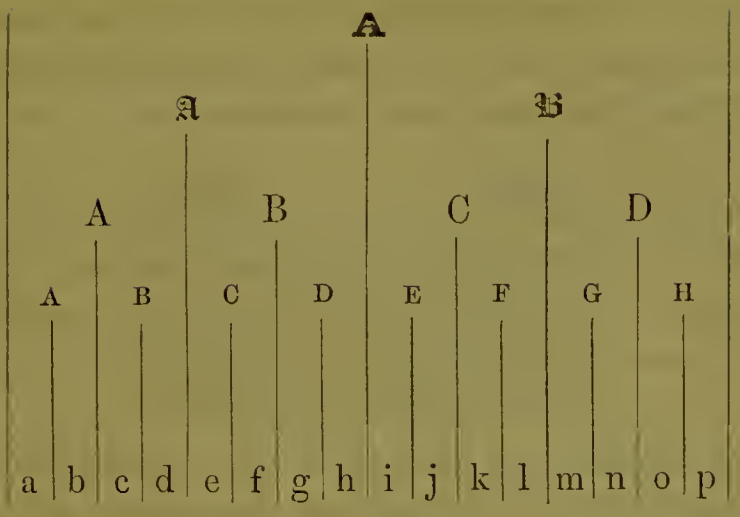
(73) Thought amenable to fixed Principles.—(74) Arrangement of Words.—(75) Application of this Arrangement.—(76) Relational Machine.—(77—81) Various Forms of Construction.—(82) Results obtainable by the Relational Machine.—(83) Resultant of Various Expressions.—(84) Power of Extensive Machine.—(85) Power of Machine analogous with process of Thought.—(86) But infinitely inferior to it.—(87) Its Use as a Calculating Machine.—(88) Deduction of Probabilities.—(89) Differential Machine.—(90) Principles of.—(91) Mechanism of.—(92) Application of.—(93) Guessing.—(94) Comparative uses of Relational and Differential Machines.—(95) Infinite perfection of the works of God.

(73.) From the laws which have been already detailed, it is apparent that thought is amenable to fixed principles. By taking advantage of a knowledge of these principles it occurred to me that mechanical contrivances might be formed which should obey similar laws, and give those results which some may have considered only obtainable by the operation of the mind itself.

(74.) In order to induce a general law from specific instances, and deduce the application of a law to a particular case by means of mechanical contrivances, we must take advantage of the geometrical arrangement of words formerly described, and denote each word by a cypher, and lastly then arrange them in such a manner that each cypher may bear its proper relation to every other cypher.

(75.) The application of the geometric arrangement of cyphers may be best represented by any contrivance, the parts of which continually divide by a hinge joint into two portions. Nothing apparently can be more simple than this arrangement; though, practically, for large series, the details are so troublesome, that it has required much more labour to bring it into a working form than I had originally anticipated, owing to the difficulty which arises from the necessity of a large number of parts being compelled to move upon the other parts of the contrivance, which is absolutely necessary to the construction of the machine.

(76) I have before me, whilst I write, seven or eight varieties of these contrivances, some of which have their fixed points at the top of the geometric series, and some at the other extremity of the same. Perhaps the construction of the latter may be illustrated by a number of lines and letters as in the annexed diagram for a series of sixteen, thus: —

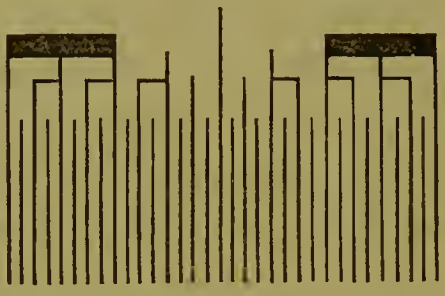


(77) In this case the fixed point of every line is at the bottom of the diagram, and each is represented as fixed upon a board. The whole is now shown as open, but it will be seen that when closed the act of opening any one of the lowest set would partially influence its corresponding cypher in the series above it. This form illustrates the principle exceedingly well, is simple in its construction, and by a proper use of readings is applicable in all cases.

(78.) Upon the whole, however, perhaps the fixed point had better be placed at the upper part of the series, and as there are some difficulties in constructing it to work as a triangle, it may be arranged to shut up as a parallelogram.

(79.) If the action of the machine is desired to illustrate by its own mechanism, the principles, then the movements must be so arranged that the

spaces of the several series must open in a corresponding way, and this may be effected by constructing it as in the annexed diagram.



If, however, the action on the cyphers is only desired, then the mechanism may be arranged by a series of bars joined together by hinges at one of their extremities, and the different cyphers may be appended in their proper places in such a way that the mechanism may be concealed. This latter plan, is perhaps one which is the most applicable for a geometric series of high power.

(80.) I have constructed machines to work by a to and fro motion, by which a great number of elements can be packed parallel; but upon the whole, an action is perhaps better represented by one bar moving upon the others. Other contrivances may be made to work upon the periphery of a circle, so that the top of the series being placed nearest the centre, opens to but a small extent for a larger range of motion between any two bars at the bottom of the series.

(81.) This kind of motion, requiring whole series of movements to move upon other movements, is a

new requisite in mechanical contrivances; or at any rate I am unacquainted with its use amongst the machines which abound in this great metropolis.

(82.) When the vast extent of a machine sufficiently large to include all words and sequences is considered, we at once observe the absolute impossibility of forming one for practical purposes, inasmuch as it would cover an area exceeding probably all London, and the very attempt to move its respective parts upon each other, would inevitably cause its own destruction. Nevertheless, those lesser machines containing but a few elements, exemplify the principles of their operation, and demonstrate those laws of induction, deduction and relation, the right use of which cannot fail to render our thoughts more accurate, and our language more precise. The best form for the readings on the machine may be illustrated as below. When the machine is shut up it will appear as printed, and by cutting it diagonally, it will give a reading when open of either None, Some, All.

None	Some	All	All	All	All	All	All	All
None	Some	Some	Some	Some	Some	Some	Some	Some
None	None	None	None	None	None	None	None	None
A	B	C	D	E	F	G	H	I

(83.) If we examine the results which can be obtained from the use of the relational machine, we observe that an action represented by an opening at any point represents a similar action upon every other element placed below it in the series, and also a partial action of every element having relation to it at the higher part of the series, hence the value of every expression, and its relation to other expressions, can be read off.

(84.) The machine, however, can do more than this; for two or more facts, or two or more assertions, can be represented by actions in a similar manner. Like the human brain, it is competent to give the resultant of any number of propositions be they ever so numerous, and show their mutual bearings upon each other.

(85). If the machine were sufficiently extensive to comprise every fact or principle which has been ascertained, then when any new fact is learnt it might be appended, and its bearings upon more general instances, or more particular cases, would be immediately shewn.

(86.) It is thus apparent that this mechanism gives an analogous representation of the natural process of thought, as perfectly as a human contrivance can well be expected to afford; but when we take into consideration the knowledge of the laws of

sequences which man possesses, we perceive how limited is the knowledge which it is competent to convey, when compared with that which is obtainable by the mind through the operation of the brain.

(87.) In examining the relations derivable from a knowledge of sequences, we must have recourse to that artificial system of notation described in the chapter on the resolution of a sentence. We must record the substantive changing in one geometric series; the nature of the change, in a second; the substantive acted upon, in a third; and the nature of the changes which it undergoes, in a fourth. If all the words in each division were placed in their proper relation, then any action on the machine indicates every principle which is inducible, or every fact which is deducible from the assertion. In like manner, the resultant of any number of assertions, is immediately shewn in the form of inductions or deductions. It is not necessary in practice to have a separate series for each subject, for the force of each word can be studied separately, together with its relations to other words, and their relation to the other subjects can be ascertained. Supposing that the machine could be made sufficiently extensive for all practical purposes, yet the labour of employing it would be so great, that persons would soon rely upon the abilities which it has pleased Providence to give to them, and not seek assistance from extraneous sources.

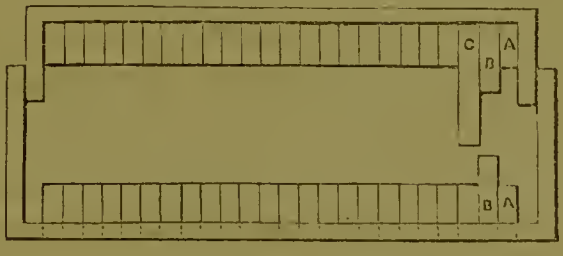
(88.) The relational machine can also be employed, to a slight extent, as either an addition, substraction, or multiplication machine, with all the advantages attached to the use of the functions of the geometric series. To all who understand the use of logarithms, this must be sufficiently apparent, without troubling my readers with a further description; more especially, as it is never likely to be practically employed for such operations.

(89.) The relational machine may be so constructed, that when one of the higher symbols is exemplified upon it by an action to an unknown extent, as in the general assertion of *some*, the deductions in the lower series will exemplify the uncertainty as to the particular ones which are effected; thus if we know that some men are short and some tall, then in the lower readings we shall find that it is impossible to indicate from that general principle, which particular ones are short and which are tall.

(90.) Not only can we take advantage of the laws of induction and deduction, and exemplify them by mechanism, but we can also in the same way, exemplify the laws of judgment by pieces of mechanism of a different description, which may be termed the Differential Machines.

(91.) In estimating the differences between any

two assertions by artificial contrivances, it is necessary to have some mechanism to represent each assertion. For this purpose we may take a wire or pin, and divide it by spaces, represented by certain symbols. Opposite to each symbol, which must represent some word or fact, we must have the means of noting whether the character of the subject is absolutely known, or unknown, by using some appendage of two different dimensions (A B, fig. 1). By this contrivance, we can accurately set out one side of the case. Opposed to this, we must use a second pin, with appendages competent to represent by three different sizes, A B C, either similarity, dissimilarity or unknown; then by bringing the two series together, an answer as to its actual, probable, possible, or negative concurrence may be obtained.



(92.) For instance, if in a definite set of symbols the value of each is known, each would be represented by a space of one. If, on the other side, the value of each was similarly represented, then the two might shut together in the space of two, and the reading would be "Yes." If on either side

some of the values of the cypher or the word were unknown, then the two when brought together, would occupy the space of three, and the reading would be "Probable"; but, if for any one cypher the value on both sides was unknown, the space occupied would be four, and the reading given would be "Possibly." Lastly, if on the two sides, any two symbols disagreed, that want of accordance would be represented by a contrivance occupying the bulk of four on the second side, and when brought together the amount would be five, for which the reading of "No" would be given.

(93.) By the differential machine it would be possible on one side to arrange all the facts or principles which should direct a judgment on a given point, by which means, when specific facts were registered on the opposite side, the concurrence, non-concurrence, probability, or possibility would be immediately shown. Perhaps this might be beneficially brought into use by those who use fixed and unchangeable creeds; for if they be arranged correctly then any deviation from them would be immediately registered. It must be apparent that such a machine would not estimate the quality of the creed, but only show whether any new creed, or portion of creed, coincided or not with the former creed. For whether the creed inferred a belief in the true God, in Mohammed, in ibises, crocodiles, or saints, in the power of the Virgin, or

winking pictures of her, or the qualities of relics, or the virtues of images, or in the parties' own inspiration, the effect would be the same, as these beliefs being assumed as true, the truth of that which is compared with them is ascertained according to them. There are many other cases where such a contrivance might be beneficially employed; for whenever passion or powerful feeling is likely to interfere with a sober and correct judgment, then the examination of each part separately is likely to be properly used when the mechanical answering upon the whole case will be, although immediately performed by a human contrivance, according to those principles which regulate the action of the brain in such circumstances.

(94.) Nothing can show more usefully than this machine, the futility of guessing at any decision without any or sufficient information upon which to form an opinion; for if, at random, certain actions be rendered on both sides of the machine, then the almost certain impossibility of ever arriving at a true concordance will be speedily found upon trial. What is true of this piece of mechanism is true of the mind, which sufficiently teaches how slow we should be to pass an opinion without a knowledge of all the facts which bear upon the question.

(95.) By using the relational and differential machines together, we are enabled to obtain the

bearing of any facts, or to arrive at any conclusion to which the mind by itself is competent. From any definite number of premises the eorrect answer may be obtained, by a proeess imitating, as far as possible, the natural process of thought.

(96.) By the natural powers of thought the mind also possesses a spontaneiety, a power by whieh bygone impressions appear, eonstituting an act of memory. These the mind treats aeeording to all the laws impressed on the brain, and moulds them into one harmonious whole to constitute an aet of imagination. This property, ever active in the fertile minds of our dramatie and novelist writers, is never exereised without due regard to the experienees which have been afforded of the sequences of events. The mere coneeption of an idea would be useless unless its relation to other ideas and other events was fully shown, and the exercise of the faculties of remembering, combining, and comparing ideas, is amply shown in man, and indicates a power of adaptation in his eerebral organization as given by Nature, infinitely superior to any human contrivanee however ingenious. We thus perceive, that whether we study the meehanical arrangements of the bones, the optical structure of the eye, the hydrostatic apparatus for the eirculation of the blood, the acoustie arrangements for hearing, the meehanism of muscular motion, the generation of force, or that physical structure

which is the instrument of the mind, we are equally astonished at the infinite perfection of their design. This cannot fail to show to man his utter insignificance in his inventive skill, as displayed in his mechanical contrivances, when contrasted with the wonderful example of creative power which his own beautiful and perfect organization affords, and must make him deeply feel the infinite goodness and power of God.

CHAPTER VIII.

ADAPTATION OF PROCESS OF THOUGHT TO ALGEBRAIC FORMULÆ.

(97). Syllogism.—(98). Algebraic Formulæ.

(97). The laws regulating the natural process of thought, can not only be exemplified by mechanical contrivances, but can also be adapted to algebraic formulæ. In logical works the notation which is used is remarkable for its extraordinary vagueness of character. Thus logicians set out the syllogism—

all men die	every Y is X
all men belong to the class of rational beings	every Y is Z
therefore some rational beings die	therefore some Z's are X's.

Upon this plan logicians exemplify what they call logical deductions, but the most casual examination will sufficiently explain why no man of sense ever employs logical ambiguities, for how possibly according to the ordinary use of symbols and words can every Y be both X and Z, and yet only some Z's be X's, for the word *is* or *be* denotes

equality, coincidence, sameness, and does not admit of limitation. In the logical system the word is used in two senses.

(98). According to the electro-biological view, the assertion, All men die, may be rendered A (assertion) = Y man + X, mortality; that is, the words man and mortality are always conjoined. According to the second assertion, we find that Y = Z rational beings—U something else, which is unknown, from which we find that Y + X = (Z + U) + X from which we know that man being mortal, some organised beings are mortal. By conducting our formulæ upon this plan, every proposition can be solved according to those true principles which men who are reputed to have common sense, conduct their operations, for no matter how many assertions are given, satisfactory conclusions based upon them can be obtained.

(99). In the comparison of two assertions, ordinary modes of applying symbols can be adopted, for according to the principles which we have developed, when the assertions are unravelled into their component parts, if every part on both sides is identical, the assertion is affirmative; if at any one part a difference exists, the assertion differs; if in any one part its nature is unknown, then the coincidence is only probable; and lastly, if at any one part the nature on both sides is unknown, then the coincidence is only possible.

CHAPTER IX.

VALUE OF THE PRONOUN *I*.

(100). Natural Process of Thought.—(101). Value of *I*.—(102). Suppression of Opinion.—(103). Effect of.—(104). Practical Application.

(100). In the human brain impressions from the external world are continually being received, are there registered, and remain to produce their influence on the comparison between new and bygone knowledge. As far as the mechanism of the brain exceeds that of any human contrivance, so is the result of the proper application of the mind more trustworthy than the artificial contrivances of reasoning by words, cyphers, or mechanical inventions.

(101). From this cause great respect is paid to any trustworthy person, when he boldly declares that he himself believes that any opinion which he promulgates is true. In writings, therefore, nothing can exceed the value and force of the word *I*, either implied or used; and although there are

not found wanting amongst the lower class of literary scribblers, persons who scoff at the Pronoun, and attempt to ridicule its use by recounting the number of times per page it occurs; yet its more abundant employment would have saved the world from much sophistry, deceit, and falsehood.

(102). Almost all untrue statements are based upon arguments by words, and the person who writes never gives his opinion unequivocally. His arguments in words throw the responsibility of the conclusion on his readers, from the facts which he has recorded; and there is nothing to show how many other facts or parts of facts he has suppressed. But if he makes an assertion of his own belief, his readers have the result of the natural process of thought, if he be but trustworthy.

(103). By avoiding the use of the word *I*, a newspaper editor in America actually conducted two journals of totally opposite politics at the same time. In both cases he shewed certain arguments, and the conclusion legitimately deducible from the premises; but he took care not to include the little word *I*, or in other words, to shew the belief which his own natural process of thought led him to adopt.

(104). In all professional subjects the opinion of the professional person should be obtained. If you

judge from a long report, you have a result of far less value than if you judge from his own opinion of the case. In the case of a lawyer, he should distinctly give his opinion upon the whole facts of the case, so a medical man should be expected to state a definite opinion from all the materials which he can collect upon the subject. In giving this opinion, a result is obtained which has been derived from the mind, the immediate work of God. In setting out an argument by words or symbols, a result is obtained by a process of mechanism devised by man.

CHAPTER X.

ON EVIDENCE AND TESTIMONY.

(105) Trials.—(106) Theoretical Perfection of.—(107) Verdict generally only one of probability.—(108) Example.—(109) Remarks.—(110) Use of the Jury.—(111) Civil Cases.—(112) The use of Words.—(113) Defendant.—(114) Contradictory Testimony.—(115) Imperfection of Trials.

(105.) Trials are employed to determine the truth of an accusation against a certain person or persons, that is, whether he or they at a certain place did something which constituted a cause which produced an effect, the whole occurrence having taken place between certain times. This constitutes the charge, for instance, "John, at No. 1, Peaceful Cottage, beat James, last Monday, at 10 o'clock." For the purpose of ascertaining whether the offence was really committed, a number of witnesses are called, and the evidence which they each received, through the medium of their senses, is recorded. If the images received upon the sensorium of the witnesses, according to their statements, correspond entirely with the images which

such a charge should have produced, the guilt of the party is said to be proved by the concurrence.

(106.) In carrying this process to the very utmost possible perfection to which the system is capable, every word should be so described that no possibility of wrong interpretation could occur. Then and only till then can the statements of the witnesses, when they express that which they receive upon the brain by symbols or words, be relied upon, and no error be likely to occur from ambiguity. When the sets of words or symbols derived from the witnesses, are compared with the words or symbols constituting the charge, and are found to exactly concur, then a mere piece of mechanism would be sufficient to show the guilt of the party.

(107.) But we rarely can procure the evidence of witnesses to prove charges in serious offences. The eye of man is shunned at such periods, and thus no one sees the deed, and the entire evidence is scarcely ever procured. In these cases, the guilt of the party must of necessity be one of probability or possibility as there cannot be an absolute concurrence between the symbols of the evidence and the symbols of the charge. Nevertheless, upon that possibility the law has wisely ordained that criminals should be convicted, and expiate their crimes by the highest punishment.

(108.) Suppose, for instance, "John is charged with killing Thomas with a knife, at 1, Miniver Place, at 2 o'clock on Monday." In this case, evidence might be adduced that John was there at that time, and that John's knife actually killed Thomas. Now, in this instance, the mode of the act of killing would not be proved but from the concurrence in all other particulars, and the total want of disagreement. John is probably guilty, and the jury would doubtless return such a verdict.

(109.) This verdict, however, is only one of high probability, and we must not forget that James, of whom no evidence was given, and against whom no charge was made, might have taken the knife from John's pocket, killed Thomas, and then put the knife back again, totally unknown to John. There can be no question but that in the annals of English jurisprudence, notwithstanding all its care, innocent persons have fallen victims from probable or possible guilt having been confounded with actual guilt.

(110.) The laws of affirmation, negation, possibility and probability, might be turned with good account to prevent this serious mischief. The accusation might be clearly set out; the evidence of the witnesses might be taken before the jury, who are manifestly the proper persons to assign a right word or symbol to the impression which the

witnesses received of the event in question. Having arranged these symbols, one by one, opposite the corresponding symbols of the accusation, a mere engine would describe the possible, probable or actual guilt of the person accused.

(111.) Although I have assumed a criminal case for the purpose of my argument, yet the same reasoning would hold good in every civil case. One man sustains a damage at the hands of a second; the charge is set out, the witnesses give their testimony, and the question of identity between the charge and testimony is one which may be determined by mechanical contrivances when the words in the two instances are accurately set out.

(112.) In every case the intervention of the jury is necessary to assign a word to express that which the witness describes, because it would be impossible to obtain witnesses who shall be enabled to declare the particular nervous fibres which were excited when the event occurred. Moreover, the examination of every word with such minuteness, would be too tedious, though it might admit of minute investigation. The meaning of every important word should be fully unravelled in every instance.

(113.) When the defendant answers a charge,

he should, if it be unfounded, admit every circumstance which is true, and deny only the circumstances which are false. By this proceeding, the attention of the jury is likely to be concentrated upon the immediate point in dispute, and thus be enabled carefully to estimate the value of the testimony adduced. By this course, the accused destroys the apparent effect of that high probability which is likely to be produced by an extensive concurrence between the charge and the evidence.

(114.) In most cases of testimony the assertions of all the witnesses do not agree. Some give evidence of one kind, some of the opposite, so that the evidence upon the same point is contradictory. In these cases, the laws of induction and deduction are applied by the jury, to judge of the value of the testimony, and that which affords most probability, or that which most coincides with former know, ledge, is received.

(115.) We thus perceive how imperfect, at best are our conclusions, even when based upon the most approved evidence. We cannot fail to observe, that however carefully a jury may investigate a case, however unbiassed and unprejudiced they may be, yet, nevertheless, their verdict, in a majority of cases, can only be considered as

proving the probability or possibility of the guilt of any person. In every instance the result is obtained by the artificial means afforded by words and language, and we should never forget that wherever words are employed, there errors may creep in.

CHAPTER XI.

ON LOGIC OR THE ART OF QUIBBLING.

(116). Logic applicable to Quibbling.—(117, 118). Quibbles by Puns.—(119). By Qualified Nouns.—(120). By Variations in Number.—(121). By the Question involving Two Answers. (122.) By Constitution of Words.—(123). By the Verb.—(124). By General Principles, with Exceptions.—(125). By Two Words for the same Thing.—(126). By Cause and Effect.—(127). By using Words contrary to well-known Principles.—(128). By Action conjoined with the use of Words.—(129). By Variations of Emphasis.—(130.) By Exalting a Probability.—(131). By Circular Reasoning.—(132). By a Question involving a False Premiss.—(133). By reasoning upon that which may be known.—(134). By changing the Word for the same thing.—(135), By a Variation of Punctuation.—(136). By begging the Question.—(137, 142). Other forms of Quibbling.—(142). Conclusion.

(116). Logic has now been the means for so many ages employed by mankind for quibbling, deceiving, and leading to wrong conclusions, that we cannot do better than restrain its application to the same derogatory purposes, and instead of shewing how, by extraordinary acumen and a high

exercise of mental power, it may serve to a good object, we shall at once describe the usual methods by which it serves for a contrary purpose.

(117). For proving what is false from any given premiss, logic is extremely convenient, as the system does not note with sufficient accuracy the signification of various words, and their mutual relations, unless, indeed, we except any very gross ambiguity in the middle term. A pun consists of good reasoning upon words having one sound or spelling, but two senses. By the natural process of thought, unless the individual is, indeed, exceedingly obtuse, the mind, as soon as the conclusion is brought before it, perceives the joke, and the auditor laughs at the deception. Example, "John, as you are light you can illuminate this passage."

(118). Puns, however, are such glaring cases of using apparently the same word in different senses, that a deception could very seldom be practised by them, yet in a less degree errors may certainly arise in that manner.

(119). One great and frequent deception which can be effected under the logical system, is by using a noun in one term, and a qualified noun in a second. But to be successful, the qualification must not be apparent, it must be under-

stood. If I say "I had a bird for dinner," then the qualification "cooked" is understood. The further removed this qualification can be placed from the noun in any argument, and the smaller it is in amount, the more successful is the quibble likely to be. A humorous story is quoted by Professor De Morgan, which is a good example of a transparent quibble of this character. "A servant who was roasting a stork for his master, was prevailed upon by his sweetheart to cut off a leg for her to eat. When the bird came upon table, the master desired to know what was become of the other leg. The man answered, that storks had never more than one leg. The master, very angry, but determined to strike his servant dumb before he punished him, took him the next day into the fields, where they saw storks standing, each on one leg, as storks do. The servant turned triumphantly to his master, on which the latter shouted, and the birds put down their other legs and flew away." "Ah, sir," said the servant, "you did not shout to the stork at dinner yesterday; if you had done so, he would have shewn his other leg too."

(120). Another common mode of deception for those who admire that course, is to link two sets of things together, and thus it has happened that when a statement has been made true in all particulars but on some trifling point, a total denial has been given to the whole, and then the auditor was

allowed to infer that the whole was not true. Example.:—"Are there not persons involved." Answer:—"No" It was afterwards discovered that there was one person.

(121). The converse method is frequently employed by unscrupulous counsel in their cross-examination of witnesses, to make a fact appear to the jury contrary to what it really is. For this purpose they ask a question as to a qualified noun, the answer to the noun being negative, the qualification positive, or *vice versâ*. For this mode of quibbling, the qualification should be as much concealed as possible. The object of this quibble is so to put a question that a direct answer either way is both partially true and partially false, thus:—"Did you go there soon?" Now either Yes or No would be partially true and partially false, because "I went there, but not soon."

(122). The value of logic to deceive or give a wrong inference, by extending or limiting the sense of a word, cannot be overrated. It is so perfect, that probably no well-instructed logician would fail to evolve an argument, and give a totally different conclusion from that which is correct. On all these occasions the error should be thrown over as many words as possible, that it would become a matter of much labour to discover its exact locality.

(123). The Verb is a word upon which the quibble may be turned. In the first place, the substantive character contained in the verb may be altered a little by attenuation or amplification, with precisely the same results as though the quibble had been made by the Noun. The quibble may be made by extending or limiting the signification of the time so little that it is scarcely noticeable, and yet the meaning may be greatly altered. At times even the effect which the Verb has upon the meaning of the Nouns to which it appertains, may be in like manner altered. Whenever we can add or subtract ever so little from the true signification, the meaning may be entirely changed.

(124). A common form of quibble amongst dishonest men is to give an answer inferring a premiss which renders a supposed fact impossible; for instance, when Dr. Wiseman was accused of taking an oath to persecute the very Protestants who tolerated him, he answered to the effect that Cardinals were not required to take the oath; and to this day nobody knows whether he took the oath or not. The quibble consists in the value of the proposition —"Cardinals are not required to take the oath," for it is possible that the general principle may be limited by an exceptional case, understood but not expressed.

(125). There is a mode of practising mendacity

which would not be immediately apparent to honourable men, who would shun such a course as derogatory to human nature, and would, therefore, never suspect its being practised. It consists in using two words to signify the same person or thing, one being used in one case, the second in the other, and then the assertion which is made of one is denied of the other. When Wiseman was reviled for the influence which some priest exerted on the mind of an old man to cut off the entire fortune from his own children to bestow it on Dr. Wiseman, he replied that the statement was false, for that his name was not mentioned in the will. The son rejoined "No, but the name of the Vicar Apostolic was," the Vicar Apostolic and Dr. Wiseman being at one time the same person. In the same reply of Wiseman, one of the most celebrated quibbles which history can afford, was also manifested, for he stated that the son was living upon the property, and enjoying it, instead of its having been bequeathed away; but judge the astonishment of the public, when the son declared that he had but a life-interest, and that the kindest of fathers, when above eighty years of age, had been induced to give the whole to the papal church. We can hardly wonder why it is almost universally felt that papists are not believable on oath, when such terrible examples of moral turpitude as the *strained* signification of a word for the purpose of suppressing the truth, and conveying an untruth would appear to

be considered by them as extremely clever and laudable.

(126). A telling mode of quibbling is much used by quacks. In this case the quibble is thrown upon causality. They enter into an elaborate argument to prove truly that something undergoes a change, and thus may become a cause; they repeat the argument upon the something which changes and becomes an effect; but the cause and effect have no manner or kind of relation, the cause being the cause of another effect, and the effect the result of another cause.

(127). There is a form of quibbling which is powerful in scurrilous writings; for instance, we may give a man credit for the love of some virtuous action, in doing something which is manifestly not virtuous, and hence, from the result, infer the contrary to that which is expressed. As if we said that A B, no doubt from a love of honesty, religion and high principle, keeps the money left to the orphan and fatherless, applies the wealth bequeathed to the friends for his own purposes, seizes upon all which he can obtain by law, and not by equity, and makes a merit of giving to charities money which morally belongs to others. The mind is first led to anticipate honesty and high principle; but in the end it discovers moral delinquencies, which it shudders to contemplate, and the villany

of the action is inferred by premises not given but intrinsically belonging to it.

(128). A quibble is sometimes practised by some action, having a definite signification, being used in addition to the words spoken; thus, if a person asks a pew-opener to shew him into a seat, and at the same time rattles the money in his pocket, the pew-opener would certainly infer that he was to receive some reward for the performance of his duties; but if the visitor on gaining a seat, took his hand out again without bestowing the gratuity, doubtless the official would be so much astonished, that his devotions for that service would be materially interfered with.

(129). The meaning of a word may be totally altered by mere change of emphasis, and hence this plan is often used for quibbling. The words from the Bible, "Saddle me an ass, and they saddled him," may be totally varied in their signification by a change of emphasis on the word *him*.

(130.) A fallacy which is frequently employed, is, to allow a question of high probability to be inferred as a certainty, and conversely, a question of certainty to be inferred as only one of high probability; as if we said, that John was found guilty of murder, therefore his innocence is impossible. So, also, a possible supposition may be extended into a

reality, and many men are ruined by investing money in concerns which are only *possibly* good. A mean in the same way may be used without reference to the variation of the limits; thus a man might be drowned in a river whose mean depth was only one inch, because occasionally it may be six feet deep. In these and many other similar ways do men too often deceive and sometimes ruin their fellow-men.

(131.) In conversation, persons frequently take two sets of words, each having the same meaning, and argue that one is true because the other is, when, in reality, neither is true. Thus "John is a tall man, because he is a person of considerable height. By this mode of quibbling the mind is thrown off from the manner in which information was got of his height, and the probable value of that assertion. This is called Circular Quibbling.

(132.) People are often thrown off their guard by being asked a reason for that which is not true, and by which they are led to infer that a falsity is true. Example, "How can Lead be turned to Gold." To answer the question centuries were spent in attempting the conversion. The question involves the understood premiss, that lead is convertible into gold.

(133.) Conversely, persons are deceived by

reasoning upon that which can be reduced to a matter of fact. Lady Morgan states, that the celebrated Denon and Champollion, told her that they saw, in Cufic characters, "There is but one God, and Mahomet is his Prophet," engraved on the chair of St. Peter. The Cardinal, to whose fertile ingenuity, and varied talents I am so much indebted for cases illustrative of many kinds of disreputable quibble, answers the assertion by long and learned arguments, coupled with personal abuse. The quibble consists in drawing off attention from the only true mode of settling the question, which Lady Morgan has already pointed out, namely, by showing the chair.

(134.) One of the most certain of all forms of quibbling is to describe the same thing by a totally different word. In this way the greater part of Paganism has been handed down, under the much-abused name of Christianity, by and for the benefit of a wily priesthood. This greatest scourge of the human race has been thus enabled for centuries not only to promulgate blasphemous fables, and carry on their selfish practices, but even to make their poor deluded followers believe that they are the only true Christians. When we find that a weak and priest-ridden peer is wheedled into acquiescence in the sacrifice of a niece, by frustrating the objects of the Most High in sending her into the world, to gratify the greedy avarice of a

degenerate Church and venal priesthood, we can only rejoice that the iniquitous act sullies not the purity of the true Christian faith, but only further opens the eyes of the public to demonstrate the horrors of Pagan imposture and superstition. After twenty millions have been spent in emancipating the African heathen, it is strange that ladies in a Christian country should be permitted to be consigned to dungeons, and in some cases cruelly tortured, to gratify the avarice and prurience of a heartless priest. It would be well if the Earl would, by embracing the doctrines of Christ, put an end to the hereditary curse which overhangs his title, of exclusively fostering the Plague-Spot of Humanity.

(135.) By a variation in punctuation a complete subversion of the meaning of words may be produced. At various times I have met with curious exemplifications of the possible mode of quibbling, by a variation in the punctuation, and once a person actually told me that he never punctuated his letters, that he might make them read in various ways if that course should be required.

(136.) Sometimes quibbles turn upon assuming a conclusion as proved, which is termed begging the question ; and at other times the mind is distracted by a second person answering away from the main point, which is an evasion of the question.

By skilful quibblers both these modes may be rendered sufficiently effective to deceive others.

(137). There is a form of quibble much practised by senators and other great men. They give a right conclusion, but conceal, increase, or alter, the whole or a part of the premises from which the conclusion has been drawn. I admit the necessity of keeping back facts at certain times, but fearing the danger of any kind of quibble, it appears to me, that a man in power should have the option of submitting or concealing the facts, rather than that he should be compelled to resort to any form of untruth whatsoever, even for the benefit of the state.

(138). By introducing hypothetical facts amongst direct assertions, an inference may be given to the mind of a second party that such fact exists, or that there are good reasons to believe the possibility of the fact. Example:—He is a good lawyer, a clever man, a person of great industry and ability, and will be admirably adapted for your purpose *if he is honest*. By this quibble the man's honesty is questioned.

(139). There is a quibble used by controversial writers, as they frequently contrive to throw the quibble upon the value of an authority; thus, the author must be wrong because Hunter says differ-

ently. This assertion involves the false premiss, that everything which Hunter says is right.

(140). It not unfrequently happens that persons quibble by denying the desire to do a particular act while they are actually engaged upon it: thus—I do not wish to be guilty of the bad taste of praising my own piece of sculpture; but yet, when I examine the charming proportion of its parts, and the beauty of its finish, truth compels me to declare that there never was any piece of work equal to it.

(141). The multitudinous quibble is generally practised by our transatlantic brethren in the formation of companies. They state a general fact in a prospectus, and then support it by various statements in newspapers, letters, etc , so that they get a combination of statements all tending to one conclusion. The popish priests use similar means to entrap victims into those dens of iniquity, called "Religious Houses;" and it is practically found that very few persons have mental power sufficient to withstand the combined and reiterated assertions of a number of people all varying in their statement, but yet tending to the same end.

(142). A rather refined quibble is occasionally practised by taking advantage of some abnormal state of the second party, when he is not likely to

see things in their true light. It is said, that by taking advantage of a fatigued state of body after the gaieties and late hours of a London season, the niece of the Earl of Shrewsbury was nearly entombed in a convent, and despoiled of her fortune of £80,000. The talented papal quibblers also take advantage of depressed states from illness, anxiety, the loss of relations, the better to act upon those whom they have marked for their purposes. I cannot learn, either at the Bank or elsewhere, that any other sect or denomination but the Papists use these quibbles as a regular system.

(143). I have now shewn how man can deceive his fellow creatures by the use of that artificial system of words and language, the power to use which has alone been bestowed by Providence upon human beings. To debase this excellent gift, is not only directly contrary to God's word and to human laws; but experience shews that the perpetrator of the offence invariably himself suffers from any attempt to deceive his fellows, and that it may be regarded as one of the highest crimes of social life. As a rule, man will not hesitate to quibble by words, when he would hesitate to tell a direct falsehood. To improve our system, let every quibble be considered as a falsehood, and the perpetrator treated accordingly. No matter how voluminous an argument may be—no matter how the truth or falsehood may be involved, a man may always be put upon his

veracity in any statement he may make, by asking him, "Do you of your conscience believe your assertion to be correct and calculated to lead to a right inference?" By this question you throw the difficulty from the work of man in his mechanism of words, to that work of God from which emanates the mind. In obedience to this recommendation, I do declare, that this work, and my treatises on which it is founded, contain, to the best of my belief, correct and true deductions from all the facts which I have been able to collect upon the structure and the mode of arrangement of the nervous system on the one hand, and the observed functions on the other; and I feel assured that the whole system is one fairly based upon the observation of nature.